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ABSTRACT

This unit attempts to interrelate the traditional biological science studies such as food webs, population changes and ecological succession to form a coherent picture of our world today, the factors that created it and the forces that continue to change it. Designed for use in the secondary schools, it is built around nine films and has seven basic topics: (1) Prehistoric life, the sequence and causes of the changing plant and animal communities; (2) Causes of climatic patterns; (3) Roles of participants in natural communities; (4) Biomes throughout North America; (5) Population; (6) Adaptations; and (7) Man's role in the natural environment. Teaching aid materials include behavioral objectives of the unit, a suggested time line, suggested methodologies, an annotated list of the nine films and suggested evaluative instruments. (MLB)

environmental education curriculum

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ENVIRONMENTAL EDUCATION PROJECT
ESEA TITLE III, SECTION 306

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A unit developed by the Environmental Education Project Staff, February, 1973; revised, January, 1974, for secondary science students.

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LIFE - PAST, PRESENT AND FUTURE

The work presented or reported herein was performed pursuant to a grant from the United States Office of Education. However, the opinions and material expressed herein do not necessarily reflect the position or policy of the U. S. Office of Education, and no official endorsement by the U. S. Office of Education should be inferred.

LIFE - PAST, PRESENT, AND FUTURE

Foreword

Students of the biological sciences study plant and animal adaptations, the theories and facts about the origin of life on this planet, population changes, food webs, biomes, and ecological succession. These topics are studied in different chapters of the book throughout the year. The ideas are seldom tied together to form a coherent picture of our world today, the factors that created it, and the forces that continue to change it. This module attempts to draw these separate topics together to form an understandable picture of our ever-changing world.

The module is built around nine excellent films, and has seven basic topics: 1) Prehistoric Life, the sequence and causes of the changing plant and animal communities; 2) The causes of climatic patterns throughout the world; 3) Roles of participants in natural communities; 4) Biomes throughout North America; 5) Factors controlling and promoting population growth; 6) Adaptations - their cause and affect; and 7) Man's role in the natural environment.

The module is designed to review, not to introduce the above topics. In three weeks, it reviews concepts presented during 36 weeks of a normal course.

The topics are developed with class activities, papers, films, and a field trip to the University of Kansas Natural History Museum.

The achievement of the stated goals is guided with behavioral objectives, teacher suggestions, field trip note sheets, and questions to the student with each activity, film, and paper. The achievement of the objectives is measured with carefully written and evaluated tests based on behavioral objectives.

Robert E King

Robert E. King
Secondary Program Specialist

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My sincere gratitude is extended to the program specialists for their tireless efforts in developing this secondary module. Curriculum development and revision has extended the working days for these staff members. My personal thanks are given to Bob King, Glenn Clarkson, and Thad Whiteaker for an outstanding job.

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The enclosed curriculum is the result of input from the project's paraprofessionals and volunteers, science teachers, Community Council members, parents, students, and interested lay citizens.

With the deepest appreciation, I acknowledge the work of the secretarial team. The constant revision, pressures, deadlines, and demands for quality work were handled in a most outstanding manner by Dorothy Booher, Sue Beattie, Joyce Hartman, and Rita Dreiling.

Donald French
Project Coordinator

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LIFE - PAST, PRESENT, AND FUTURE

Module Goals: This module seeks to reinforce and expand knowledge and values concerning the following areas:

1) Prehistoric life - the sequence and causes of changes in plant and animal communities.

2) Weather - its relationship to plant and animal communities, its causes, and basic patterns over the North American continent.

3) Roles of organisms in the food webs of various types.

4) North American biomes - their historical origins and natural communities.

5) Population growth - factors controlling and promoting growth in natural and man-created communities.

6) Adaptations - their cause and affect.

7) Man's role in the natural environment.

USE OF TEACHING MATERIALS

The suggested time line (pages 2 - 3) for this module is provided to allow easier planning.

The "Module Materials List" (page 4) indicates the supplies you need to obtain to teach the module. The materials are listed in the sequence required for class use.

Film descriptions (pages 5 - 6) describe suggested and optional films.

Pages 7 and 8 provide a brief summary of the development and use of the behavioral objectives in this module. The behavioral objectives (pages 9 - 12) indicate the concepts and abilities that most of your class should gain from studying this module.

The posttest (pages 13 - 22) for this module is included with the correct answers circled. This allows you to see the types of questions keyed to the behavioral objectives. Please do not teach the questions, but use the behavioral objectives. Many objectives concern concepts which require interpretation and extrapolation. Teaching the test questions requires only rote memorization. Student pre and posttest results are reported using this form.

Pages 24 - 26 are two optional student papers which could be duplicated and discussed.

The rest of this mannual contains the papers available in the student mannual. Following each one of the student papers, you will find sheets of green paper. These pages contain: 1) Behavioral objectives tied to the paper; 2) Suggestions for presenting the papers; and 3) Answers to the student self-test questions. Particular attention should be given to the film material <u>before</u> presenting the film.

Suggested Time Line for Module Activities

This module has several optional activities, and many films which may be difficult to schedule. Therefore, the time line is written in the ideal sequence of events with the time required for teaching each activity indicated in parenthesis. Determine which optional activities you wish to schedule, and schedule the films you wish to use. After you know your film schedules, tailor the time line to your classroom needs. The day, or days planned for each activity may be noted in the blank spaces to the left of each paper to be used.

Day

Before the Field Trip

Arrange the field trip date with the project staff, and obtain the student pretests. Obtain approval for the field trip dates from the building principal (use Paper P-2). Invite him to visit the field trip.

Locate the classroom materials and begin duplicating all required forms and desired materials listed on page 4, "Module Materials Lists."

_____30 min. 1. Give the pretests. Return all tests and answer sheets as soon as possible to the project for scoring.

_____30 min. 2. Hand out student books, read and discuss the "Introduction," Paper A.

Duplicate page B-2, if you wish to use it in class.

_____60 min. 3. View and discuss the film Time-Lines and Events, using Paper B.

_____30 min. (optional) 4. Read and discuss Paper C, "Radioactive Dating."

_____40 min. 5. Read and discuss Paper D, "The Changing Earth."

Duplicate page E-4 if desired.

_____60 min. 6. View and discuss the film, Earth Science: Parade of Ancient Life, using Paper E.

Duplicate page P-3. Send parental permission slips home.

_____40 min. 7. View and discuss the film Origin of Weather, using Paper F.

Duplicate page G-4, if desired. Locate an overhead projector.

_____20 min. 8. Assign each student the task of finding the foods and predators for one of the organisms in Paper G, "A Kansas Food Web."

_____30 Min. 9. Do the exercise and discussion of Paper G, "A Kansas Food Web."

_____30 min. 10. Read and discuss Paper H, "Biomes in the United States." Remind students to return their parental permission slips.

Duplicate page I-3, if desired.

_____60 min. 11. View and discuss the film Life Zones of the Central Rockies, using Paper I.

Duplicate page J-3, if desired.

_____60 min. 12. View and discuss the film Sand Dunes to Forest: Ecological Succession, using Paper J. Remind students to turn in parental permission slips.

_____50 min. 13. View and discuss the film Population Ecology, using Paper K.

_____70 min. 14. Read and discuss Paper L, "Survival - What Does it Take?" View the film World in a Marsh. Try to get all parental permission slips collected!

_____60 min. 15. View and discuss the film Darwin and the Theory of Natural Selection, using Paper M, "Adaptation: Their Causes and Results."

_____20 min. 16. View the slide-tape presentation on the creation and function of a natural history museum.

_____15 min. 17.
1. Obtain a close approximation of the number of students taking the trip.
2. Call the Environmental Education Office to confirm the number of students and arrangements for the substitute. Leave a quick summary of lesson plans for the substitute.
3. Give students the "Dress, Behavior, and Guidelines" lecture provided on page P-4.

Duplicate optional papers, "Why Do Robins Lay Blue Eggs?" or "Safety in Numbers" pages 24-26, if desired.

_____30 min. (Optional) 18. Read and discuss one of the optional papers "Why Do Robins Lay Blue Eggs?" or "Safety in Numbers." The film Evolution may also be used.

19. Field Trip - 3½ hours. Give the substitute teacher her instructions. Bring student permission slips. Lead a small group if possible.

_____40 min. 20. Read and discuss Paper N, "The Future: What Does it Offer?"

_____60 min. 21. View parts 1 and 2 of Tragedy of the Commons. Read and discuss Paper O.

_____40 min. 22. View and discuss parts 3 and 4 of Tragedy of the Commons.

_____30 min. 23. Review the field trip worksheets and concepts covered in this unit as summarized by the behavioral objectives.

_____40 min. 24. Give the post-module test. Fill out the unit evaluation forms, and return the tests and forms to the project office. Test results will be returned in 10 school days.

Module Materials List

The following list contains the materials which you could use to teach this module. The materials are organized in the sequence of use.

1. Teacher's Guide to the Module.
2. One "Life - Past, Present, and Future" student booklet per student.
3. Three "Requests to the Principal for Field Trip" forms per trip. (Duplicate page P-2)
4. Pre-module tests and answer sheets.
5. Pre-module tests results - 10 days after returning the answer sheets to the project.
6. One "Parental Permission" sheet per student and 10 extra copies/class. (Duplicate page P-3)
7. One worksheet per student for Paper B, "Time-Lines and Events." (Duplicate page B-3)
8. One worksheet per student for Paper E, "The Parade of Ancient Life." (Duplicate page E-4)
9. One food web per student for Paper G, "A Kansas Food Web." (Duplicate page G-4)
10. Five food web transparencies for use with Paper G, (following Paper P) and an overhead projector.
11. One worksheet per student for Paper I, "Life Zones of the Central Rockies." (Duplicate page I-3)
12. One worksheet per student for Paper J, "Why Do Communities Change?" (Duplicate page J-3)
13. The slide-tape series on the K. U. Museum. Schedule in advance and pickup from the Environmental Education Office.
14. Class sets of optional papers "Why Do Robins Lay Blue Eggs" or "Safety in Numbers." (Duplicate pages 24-26)
15. Field trip worksheets and clipboards will be supplied by the Environmental Education Project.
16. Post-module teacher evaluation packet (to be returned).
17. Post-module tests and answer sheets.
18. Post-module test results.

Film Descriptions

The following 16 mm films may be obtained from the Topeka Public Schools Audio-Visual Department. The films are listed in the sequence recommended for this module.

Time, Lines and Events - color, 19 min. Churchill, 1965

This film dramatically illustrates the relationships between prehistoric and present-day events using series of time lines. It effectively places man's history in perspective with that of the world.

Earth Science: Parade of Ancient Life - color, 14 min. University of Indiana

Examines the evidence concerning the origin and development of living forms, providing a general framework for fossil study and for the appreciation of earth history and paleontology as fields of investigation. Film shows specimens, reconstructions, and dioramas representing typical life forms in Paleozoic, Mesozoic, and Cenozoic eras. Surveys the evidence for organic evolution and changes in climate and landforms. Shows the relationship of ancient life to our present-day natural resources.

Origins of Weather - color, 13 min. EBE, 1963

This film explains how the earth is protected from extremes of heat and cold by the surrounding thin layer of atmosphere. Shows how the sun's heat is distributed by moving masses of air, and how activities of cold and warm fronts produce constantly changing weather conditions.

Life Zones of the Central Rockies - color, 21 min. IFB

Shows by excellent close-up photography and explains by diagrams, the community of living things adapted to the situation of each of the five life zones of the Rockies. The summary reviews the factors that make the difference in the life-zones; in plant and animals relationships within their environment; and suggests that all over the world these factors may be seen functioning. This is not just a parade of plant and animal life through the scenery. It is instead, a display of the inter-relationships that encourage a variety of adaptations for survival, as seen in the life-zone concept of organization. An excellent ecological study, especially appropriate to our own area.

Succession From Sand Dune to Forest - color, 16 min. EBE, 1966

Illustrates the process and general principles of ecological succession by which an area slowly and continuously changes until it becomes a stable natural community. Photographed in the dunes at the southern end of Lake Michigan, shows one of the earliest and most thoroughly studied examples of this process. An excellent ecological study of changing food webs in communities undergoing succession.

Population Ecology - color, 19 min. EBE, 1971

A good film analyzing the effects of the environment in controlling population growth rates. The last portion on human growth rates is becoming dated, but the rest of the film will always remain factual.

World in a Marsh - color, 35 min. National Film Board of Canada

An excellent film showing a few of the many niches present in a marsh community. Examines, in passing, the relationship between predation, competition, and reproduction efforts of frogs, grebes, salamanders, and dragonflies.

Darwin and the Theory of Natural Selection - color, 14 min. Cor, 1968

The film documents parts of the young Charles Darwin's voyage on the H.M.S. BEAGLE, which resulted in discoveries having profound effects on nearly every field of human knowledge. Through Darwin's observations made on coasts and islands of South America, and experiments made in England, we see how the scientist developed his Theory of Natural Selection. For this new film, many rare views of animal and plant life were photographed on the Galapagos Islands. The film accurately reports the scientific theory which has, unfortunately, had many distorted interpretations.

Evolution - color, 10 min. (optional) National Film Board of Canada

The evolutionary process is portrayed by a cast of zany characters. The general sequence of life; a wide variety of adaptations; successful and unsuccessful mutations are all depicted. This film could be useful entertainment for all students but is not a substitute for the film above.

Tragedy of the Commons - color, 23 min. King, 1971

Drawn from an article by Garrett Hardin, the film begins with farmers reaping the benefits, but not the damages, from a common pasture land. The film moves on to examine earth as a commons shared by all people. The film is designed to stimulate student discussion, has a superb teachers' manual, and should not be presented in less than two hours.

A Word About Behavioral Objectives

The goals of this module are defined through the use of behavioral objectives. The behavioral objectives establish a predetermined goal toward which learning is to be directed and by which attainment may be measured. This unit is intended to develop student changes in both the cognitive (knowledge) and the affective (attitude) domains. The behavioral objectives for this unit contain these basic parts:

1) The concept, or skill being evaluated.
2) The method by which the evaluation will occur (multiple-choice).
3) The expected criterion (percent of students who should correctly respond).
4) The Bloom's taxonomy level at which the concept will be tested.
5) The audience (participating students).
6) The expected behavior (selecting the best answer).

The present trend in education is toward stricter educational accountability. Behavioral objectives help define some of the desired outcomes for which education can be accountable.

Student learning is not all at the same level. For example, direct recall of a fact requires fewer mental manipulations than applying a concept to a new situation. One system for indicating the level of difficulty of a desired response is through the use of Bloom's taxonomy. The higher the Bloom's number assigned to an objective, the higher the level of desired competence with a particular concept. Following are descriptions of Bloom's levels assigned to each objective.

Cognitive Objectives

Knowledge Level	Intellectual Level (Cognitive)
1.12 Knowledge of Specific Facts	2.10 Translation
1.21 Knowledge of Convention	2.20 Interpretation
1.22 Knowledge of Trends and Sequences	2.30 Extrapolation
1.23 Knowledge of Classifications and Categories	3.00 Application
1.24 Knowledge of Criteria	4.10 Analysis of Elements
1.25 Knowledge of Methodology	4.20 Analysis of Relationships
1.30 Knowledge of Universals and Abstractions in a field	
1.31 Knowledge of Principles and Generalizations	
1.32 Knowledge of Theories and Structures	

Affective Objectives

1.0 Receiving Level
- 1.1 Awareness
- 1.2 Willingness to Receive
- 1.3 Controlled or Selected Attention

2.0 Responding Level
- 2.1 Acquiescence in Responding
- 2.2 Willingness to Respond
- 2.3 Satisfaction in Response

3.0 Valuing Level
- 3.1 Acceptance of Value
- 3.2 Preference for a Value
- 3.3 Commitment

4.0 Organization Level
- 4.1 Conceptualization of a Value
- 4.2 Organization of a Value System

Affective Objectives
(Continued)

The following behavioral objectives are intended to give teachers direction during the teaching of this unit. The behavioral objectives define only key concepts basic to the entire unit. They do not define all the learning experiences that will occur. The objectives will be revised as more student data becomes available. This data will provide the necessary information to calculate realistic criterion levels.

Please teach with the objectives, not the test questions, in mind. For the knowledge level objectives, students are expected to know specific things. However, for the intellectual level objectives, students are expected to take knowledge, apply it to an unfamiliar situation, and determine the best answer. Teaching the test question turns a level 2, 3, or 4 test question into a level 1, or knowledge level question.

Behavioral Objective Number	Test Question Number	Concept Tested	Bloom's Taxonomy Question Level	Pre - Post Growth Criterion	Activities Developing the Objectives
1		Attitude questions are answered completely and truthfully (as measured by a and b below). a) Ninety percent of all students will respond to each opinion question. b) No more than 10 percent of the students will use patterned responses to unit evaluation questions.	2.2a		all
2	70	Environmental Education Project Modules are worth studying. *Posttest question only.	3.2a	70%	all
3	51	All schools should teach more about the ways the environment affects people and people affect the environment.	3.2a	10%	all
4	1	Interpret and select a time line of the earth showing the relative positions of dinosaurs and primitive ocean life.	2.20c	25%	B,D,E,P
5	21	Select the correct relationship between the duration of man's existence and that of the world.	1.12c	25%	B,D,E,P
6	2	Select the best method for accurately measuring the age of a fossil.	1.25c	20%	B,C,P
7	22	Indicate that climates and land forms undergo continuous, but slow, modification.	1.31c	20%	B,D,F,H,P
8	3	Given a hypothetical problem, indicate that the animals and plants on both sides of a new land bridge will undergo population changes.	2.30c	25%	D,H,M,P
9	23	Select the sequence of appearance for classes of the vertebrate animals.	1.22c	30%	D,E,P
10	4	Apply the concept "the normal fate for most species is extinction," to a specific problem.	3.00c	25%	D,E,H,L M,N,P
11	24	Given a series of graphs, select the one indicating an increasing diversity of animal and plant species in the world in recent eras.	2.20c	30%	B,D,E,M,P
12	5	Indicate that many animal and plant species probably left no fossil record.	1.31c	30%	E,P

Behavioral Objective Number	Test Question Number	Concept Tested	Bloom's Taxonomy Question Level	Pre - Post Growth Criterion	Activities Developing the Objectives
13	25	Indicate that much of the energy we use today was stored millions of years ago by plants.	1.23c	35%	E,N
14	6	Indicate that warm air from the equator warms the polar regions of the earth.	1.30c	40%	F,P
15	26	Select at least two of man's activities which may affect the climate of our planet.	1.12c	30%	F
16	7	Indicate that the middle latitudes of both hemispheres have the most rapidly changing weather patterns.	1.31c	30%	F,P
17	27	Indicate that as warm moist air is cooled and thrust upward, cloud formation will occur.	1.12c	30%	F,I,P
18	8	Correctly label two common animals and/or plants with the terms decomposer, consumer, or producer.	2.10c	35%	G,I,L,P
19	28	Apply a correct set of labels to a food chain containing producers, consumers, and decomposers.	2.10c	25%	G,I,L,P
20	9	Given a food chain, select a population that would increase as a result of a decrease in another animal's population within the food chain.	2.30c	25%	G,I,K,N,P
21	29	Given a food chain, apply the concept "Producers supply more food than their consumers" to select the population in the chain best able to feed large numbers of animals.	3.00c	25%	G,K,P
22	10	Select temperature, rainfall, history, and human actions as the factors which most influence the animal and plant life of today's world.	1.31c	20%	F,H,P
23	30	Select a probable food chain for the middle latitude grassland, middle latitude deciduous forest, or northern coniferous forest biomes.	1.23c	35%	H,I,P
24	11	Select the environmental changes most responsible for encouraging succession in a forest.	1.24c	20%	J,K,P
25	31	Indicate that the succession moves from simple to complex food webs.	1.31c	20%	J,N,P

Behavioral Objective Number	Test Question Number	Concept Tested	Bloom's Taxonomy Question Level	Pre - Post Growth Criterion	Activities Developing the Objectives
26	12	Apply the concept, "successful animals and plants usually alter their environment until they are no longer as successful," to a specific problem.	3.00c	20%	J,K,L, M,N,P
27	32	Given a verbal description of a change which would remove a population from a state of equilibrium, select an appropriate graph showing the population before and after the change.	3.00c	25%	K,P
28	13	Apply the concept "all differences between species represent adaptations for survival in the niches occupied by the species" to a specific animal.	3.00c	20%	L,M,P
29	33	Apply the definition of "niche" to select the information required to best define an animal's niche.	3.00c	20%	L,M,P
30	14	Use the law "Survival of the fittest" to select the most essential characteristic of a mutation with adaptive value.	3.00c	25%	L,M,N,O,P
31	34	Apply the concept "Organisms are fit only when many generations of their offspring can reproduce successfully" in evaluating the successful human society.	3.00c	20%	L,M,N,O,P
32	41-50	Apply the two concepts, "Control by society is essential if the environment is to be managed properly, for the individual who abuses the environment gains most of the advantage, while all of society shares the loss"; and "Humans should strive to leave future generations the social structure, resources, and environmental quality required for leading lives as fulfilling as our own," to 10 specific areas of conflicting value judgments.	1.2a 3.3a	10%	N,O,P
33	15	Interpret the film, Tragedy of the Commons, and select the best summary statement of the film's message.	2.20c	30%	O
34	35	Select the best description of the bone arrangement of large animal fossils.	1.22c	40%	P
35	16	Select the class of modern animals most like the first vertebrate that left fossil remains.	1.22c	40%	B,E,P

Behavioral Objective Number	Test Question Number	Concept Tested	Bloom's Taxonomy Question Level	Pre - Post Growth Criterion	Activities Developing the Objectives
36	36	Select the correct statement about physical changes occurring during the evolution of horses.	1.22c	40%	P
37	17	Match a biome with three adaptations unique to the animals of that area.	2.20c	25%	H,M,P
38	37	Select the source of most moisture received in Kansas.	1.12c	30%	F,P
39	18	Match a biome with three adaptations unique to the plants of the area.	2.20c	25%	H,M,P
40	38	Select the factors which most limit the populations of large carnivores.	1.31c	30%	K,P
41	19	Given a description of egg size and shape, select the probable nest location and chick maturity at hatching.	2.30c	20%	P
42	39	Indicate that albino birds do not reproduce as successfully as other birds and have excessive feather wear.	1.22c	35%	P
43	20	Given descriptions of cowbird nesting, eating, and chick-care behaviors, select the incorrect statement.	1.12c	40%	P
44	40	Apply the concept "animal species with high mortality rates tend to produce many young which require little care" to a specific problem.	1.31c	30%	G,M,P

CLASS PERFORMANCE SUMMARY SHEET

The following pages indicate how your class(es) responded to the pre and post-module tests. The following code is used throughout the test.

A - Percentage of students responding correctly on the pre-module test.

B - Percentage of students responding correctly on the post-module test.

C - Percent growth expected between pre and post-module tests.

D - Phi score for the test item. This score shows the quality of the test questions. Phi scores below 25 indicate either a poor test item or a topic that was not taught well in the unit. Phi scores above 40 indicate a very good test item which was well taught.

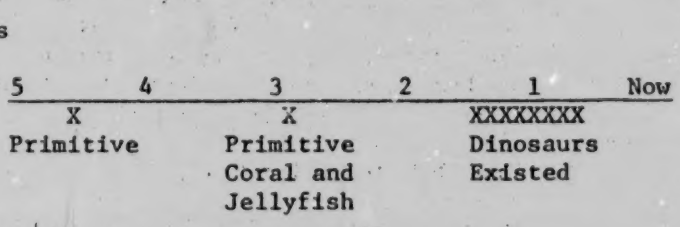
The opinion questions have two scores listed for each test result. "+" scores indicate the percentage of students agreeing with the statement and "-" scores indicate those disagreeing. The students with no opinion make up the remaining and unreported percentage.

The correct answers are circled.

1. Which of the time lines below is most accurate?

A	B
25%	
C	D

A.



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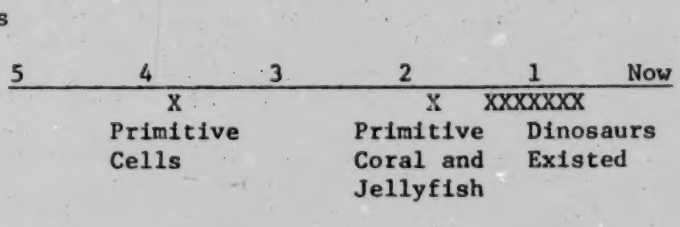
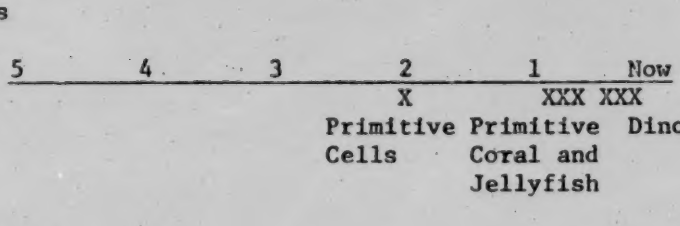
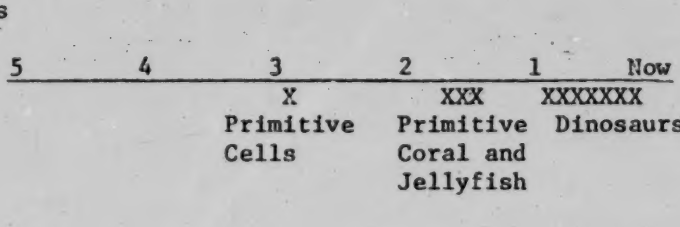


(C.)



D.



2. Which measurement would allow the most accurate determination of the age of a new fossil?

A B
20%
C D

A. The thickness of rock layers above the fossil can be measured.
(B) The ratio of radioactive and non-radioactive atoms can be measured.
C. The size and shape of the fossil can be measured.
D. The location of the fossil in the rock can be compared to the location of other fossils.

3. Two very large islands with similar climates were separated for 10 million years, then rejoined by a land bridge. Select the best prediction (more than one might be possible).

A B
25%
C D

(A.) Populations of most plants and animals on both islands would be changed.
B. Populations of most animals on both islands would be changed.
C. The land bridge should cause few changes in either island, since 10 million years is too short to develop new species.
D. Plants and animals on one island would be eliminated by species from the other island.

4. Which statement would be true about the species of trees and animals living in a forest 100 million years ago?

A B
25%
C D

(A.) Most species no longer exist, and new species have developed.
B. Most species have changed a little and still exist.
C. Most species have changed a lot and still exist.
D. Most species exist without change, and new species have been added.

5. Select the best statement.

A B
30%
C D

A. We have found fossils of most extinct species of animals.
B. We have found fossils of very few extinct species of animals.
C. Nearly all species of extinct animals left fossils, but men haven't found them.
(D.) Many extinct species of animals probably left no fossils.

6. The polar areas of earth receive most of their warmth during the winter from:

A B
40%
C D

A. radiant energy from warm soil.
B. direct sunlight energy.
(C.) warm air from the equator.
D. They receive no warmth during the winter.

7. In which biome will weather undergo the most frequent and rapid changes?

A B
30%
C D

A. Tundra
B. Northern Coniferous Forest
(C.) Middle Latitude Forest
D. Tropics

8. Foxes and oak trees have a part in the forest food web. What are their primary roles?

A B

A. Oak tree - producer; Fox - 1st order consumer.
35% B. Oak tree - 1st order consumer; Fox - producer.
C D C. Oak tree - 2nd order consumer; Fox - 1st order consumer.
(D.) Oak tree - producer; Fox - 2nd order consumer.

9. Study the food chain: Grass → Rabbit → Bobcat → Bacteria
If the bobcat population becomes much smaller, you would soon find an increase in the number of:

A B

25% (A.) Rabbits B. Bobcats C. Bobcat Hunters D. Bacteria
C D

10. The kinds of organisms living today near Topeka were least influenced by which of the below?

A B

A. Temperature and rainfall C. Man's activities
20% B. History of our continent (D.) Third and fourth-order consumers.
C D

11. Which pair of changes are usually responsible for causing succession in a young forest?

A B

A. Changing climate, particularly rainfall and temperature.
20% (B.) Changing the quality of the soil and increasing shade.
C D C. New tree and animal diseases.
D. Competition between second and third-order consumers.

12. A mutation allowed blue stem grass to produce much more seed. Which one of the things below would probably happen under natural conditions?

A B

20% A. Blue stem competitors would become extinct.
C D (B.) More blue stem seed would be eaten, and its population would not increase greatly.
C. Blue stem grass would become the main plant on the prairies.
D. Other grasses would take pollen from blue stem grass and begin to reproduce vigorously.

13. Which characteristics of frogs are adaptations which help it survive in its niche?

A B

A. 2,5 B. 1,4,5 C. 2,3,4,6 (D.) 1,2,3,4,5,6

20%
C D

1. Lungs
2. Slimy skin
3. Eggs laid in water
4. Puffs up when frightened
5. Loud mating calls
6. Bowlegged front legs

14. Which one of the facts below is most useful in determining the "fitness" of a new mutation in a tapeworm?

A B

A. The worm produced five million eggs.
25% (B.) Four of the worms' eggs became tapeworms and reproduced.
C D C. The worm required only half the food needed by other worms.
D. The worm grew twice as long as other worms.

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15. According to the arguments presented in the film, "Tragedy of the Commons," which of these statements best summarizes man's future?

A. Man will not abuse his environment if <u>everyone</u> is given education and the right to follow his own conscience.
B. Technology will take care of the world's problems, since it rapidly changes to fit the needs of each nation.
(C.) Unless governments throughout the world take <u>strong</u> steps to control population growth and environmental abuse, the quality of life will worsen.
D. The United States has enough land and resources to care for our population at the rate it is growing.

16. Which one of these groups of animals are the oldest?

A. Dinosaurs (B.) Fish C. Swimming Birds D. Rodents

17. Broad feet, small ears, and fur that changes color are adaptations for this biome.

(A.) Tundra C. Middle Latitude Deciduous Fores
B. Northern Coniferous Forest D. Tropics

18. Vines, large tree trunks, and branches which form a rounded pattern are all adaptations for which biome?

A. Tundra (C.) Middle Latitude Deciduous Fores
B. Northern Coniferous Forest D. Desert

19. Which nest will contain pear-shaped, large eggs?

A. Nest "a" is in a wheat field and the young are fed by the mother for two weeks.
B. Nest "b" is in a hole in a tree and the young are fed by the mother for four weeks.
(C.) Nest "c" is flat and on a rock ledge, the young feed themselves after hatching.
D. Nest "d" is in a hole in the ground, and the young feed themselves after hatching.

20. Pick the <u>incorrect</u> statement about cowbirds.

(A.) They take better care of their young than most birds.
B. They lay more eggs than most birds.
C. They are parasites on other birds.
D. They feed on seeds and insects.

21. Cro-Magnon and modern man have lived:

A. for about one-third of the earth's existence.
B. for about one-tenth of the earth's existence.
(C.) for less than one-ten thousandth of the earth's existence.
D. during half of the time since dinosaurs died.

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22. Which statement is true about North America during the last 100 million years?

A B
20% C D

A. Land elevations and climates have remained fairly stable.
B. Land elevations, but not climates, have greatly changed.
C. Climates, but not elevations, have greatly changed.
(D.) Land elevations and climates have both changed greatly.

23. Which of these sets of animals is arranged according to the age of their oldest fossils?

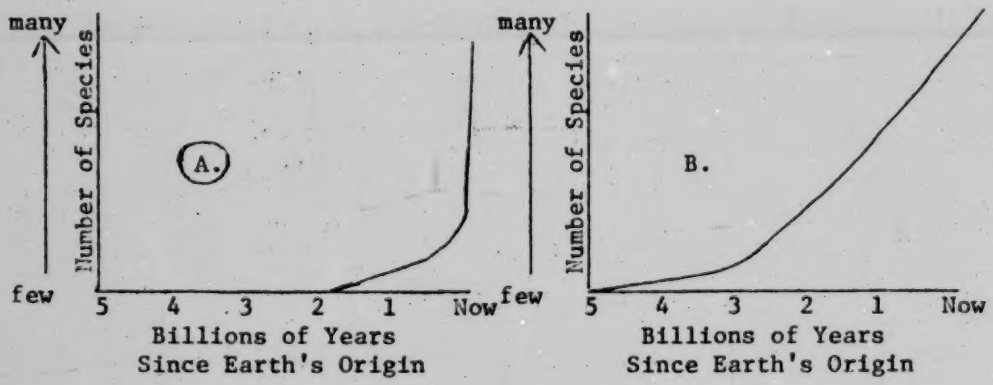
A B
30% C D

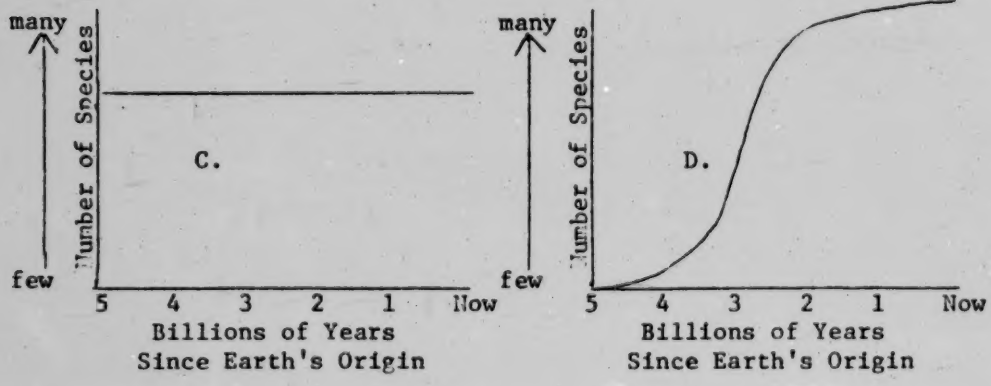
Oldest Fossils ----------Most Recent Fossils

A. amphibians ------ reptiles ------ fish ------ mammals
(B.) fish ------ amphibians ------ reptiles ------ mammals
C. amphibians ------ fish ------ mammals ------ reptiles
D. fish ------ reptiles ------ mammals ------ amphibians

24. Select the graph which best shows how the number of different species of plants and animals have changed since the earth began.

A B
30% C D





25. Most of the energy used in the United States this year:

A B
35% C D

(A.) was stored millions of years ago by plants.
B. was made from rocks containing energy from the earth's hot core.
C. was created from water power.
D. was made using nuclear energy.

26. Select the answer which lists two of man's activities which may most affect the climate of the world.

A. 1,4 (B.) 2,3 C. 1,2 D. 3,4

1. Heat is released when we burn fossil fuels.
2. Carbon dioxide is released when we burn fossil fuels.
3. High-flying planes reach the upper atmosphere.
4. We are cutting forests and building lakes.

27. Which one of the following things causes cloud formation?

A. Sunlight striking the atmosphere above lakes.
B. Warm air pushing and warming cool air.
(C.) Cold air pushing and cooling warm air.
D. Dew and water evaporating on warm days.

28. Select the correctly labeled food chain.

A. Corn (decomposer) → Mouse (consumer) → Cat (consumer) → Dies → Soil Bacteria (producer)

B. Corn (scavenger) → Mouse (consumer) → Cat (consumer) → Dies → Soil Bacteria (producer)

C. Corn (consumer) → Mouse (producer) → Cat (producer) → Dies → Soil Bacteria (scavenger)

(D.) Corn (producer) → Mouse (consumer) → Cat (consumer) → Dies → Soil Bacteria (decomposer)

29. Study this food chain.

Water Plants → Snails → Small Fish → Big Fish → Bacteria

If man lived on only one kind of food, which organism in this food chain would feed the most people?

A. Snails B. Big Fish (C.) Water Plants D. Small Fish

30. Pick a common food chain for the Northern Coniferous Forest.

(A.) Birch Tree → Porcupine → Fisher
B. Shrubs → Cottontail Rabbit → Weasel
C. Moss → Lemming → Wolverine
D. Seeds → Kangaroo Rat → Rattlesnake

31. Which statement best explains population changes during succession?

A. The variety of animals decreases as succession advances.
(B.) The variety of plants and animals increases as succession advances.
C. The variety of plants and animals remains about the same as succession advances.
D. Ecologists cannot determine what will happen over the long time required for succession.

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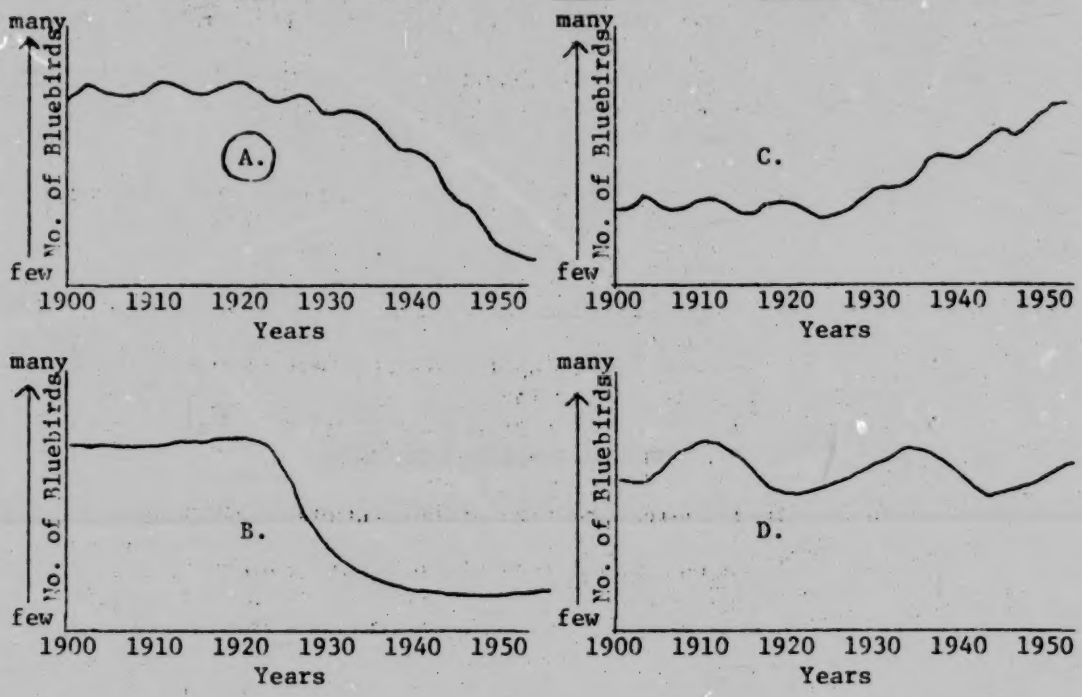
A B

25%
C D

32. In 1920, starlings first appeared in Kansas. Starlings and bluebirds use the same type of nest sites. The starling's population grew rapidly. Which graph would best show the bluebird's population?



A B

20%
C D

33. Which of the following kinds of information are required to define an animal's niche?

A. 2,3,7,8 B. 2,3,5,7 C. 1,4,6,8 (D.) All 8 are required

1. Food eaten
2. Home requirements
3. How it looks for food
4. Predators
5. Mating behavior
6. Competitors
7. Temperature requirements
8. Summer and winter habitat

A B

20%
C D

34. One of nature's laws is "survival of the fittest." Using this law, which one of these future human societies would be the most "fit"? Use only the information provided.

(A.) A kept its population at one million people for thousands of years.
B. B eliminated all human and animal disease.
C. C produced a pollution-free environment and controlled all domestic plant parasites.
D. D reproduced at a high rate for over a century.

A B

40%
C D

35. Which answer is correct about fossils of large animals?

A. Most bones will be arranged in a life-like position because mud forms a protective case around the body.
B. The animal's bones will be scattered through several layers of rock.
(C.) The animal's bones will be flattened into one layer of rock.
D. Answers "A" and "B" are both correct.

36. Choose the correct statement about the evolution of horses.

A. Most of their evolution has occurred since modern man appeared.
B. Their size has increased, but their teeth are smaller for chewing grass.
C. Their toes have gone from four to one, and their horns have disappeared.
(D.) Their legs, teeth, and skull have all become larger.

37. Most of the moisture for Kansas is picked up over water lying to the:

A. North (B.) South C. East D. West

38. What limits the populations of most large meat-eating animals?

A. Migration and predators
B. Predators and low birth rates
C. Migration and parasites
(D.) Starvation and parasites

39. Which of these statements about albino birds is true?

A. Light-colored feathers wear longer, but females are more easily seen in their nests.
(B.) Light-colored feathers wear out quicker and not as many young are born.
C. Color has nothing to do with feather wear, but albinos have trouble attracting mates.
D. Light-colored feathers wear out quickly, but albino birds still mate and raise young easily.

40. Animals which are first-order consumers with many predators tend to:

(A.) Produce <u>many</u> young which mature <u>rapidly</u> and soon care for themselves.
B. Produce <u>many</u> young which mature <u>slowly</u> and require much protection.
C. Produce <u>few</u> young which mature <u>rapidly</u> and soon care for themselves.
D. Produce <u>few</u> young which mature <u>slowly</u> and require much protection.

PART B

Your answers on the last part of this test will be used to determine what you think about some of the ideas discussed in the "Life - Past, Present, and Future" module.

Mark the direction society should take on each of the positions below.

Use this code:

A. Society should take strong steps toward the goal.
B. Society should move toward this goal, but slowly.
C. Society should remain as it is.
D. Society should move slowly to oppose this goal.
E. Society should take rapid steps to oppose this goal.

____ +A-	____ +B-	41. Americans should try to waste as little oil, land, and metal as possible so that future generations may use these resources.	A B C D E
____ +A-	____ +B-	42. Anyone should be fined for allowing land to erode when it could be protected at a reasonable cost.	A B C D E
____ +A-	____ +B-	43. Starting in 1980, every family which gives birth to its third or more child should pay more taxes for each new child.	A B C D E
____ +A-	____ +B-	44. New York City has over 26,000 people per square mile. Topeka has 3,400 people per square mile. For the good of the people living in cities, no city should be allowed to have more than 15,000 people per square mile.	A B C D E
____ +A-	____ +B-	45. A world-wide organization should have power to regulate the fishing of all oceans by all countries.	A B C D E
____ +A-	____ +B-	46. Medical and agricultural research should be well funded at all times.	A B C D E
____ +A-	____ +B-	47. Americans should develop new kinds of plants that can partially replace our present crops.	A B C D E
____ +A-	____ +B-	48. I should be able to use the environment any way I want without government restrictions.	A B C D E
____ +A-	____ +B-	49. The United States should work to encourage every country to bring its population growth under control.	A B C D E
____ +A-	____ +B-	50. Large cities should be required to purify their sewage water better than small towns.	A B C D E
____ +A-	____ +B-	51. All schools should teach more about the ways the environment affects people and people affect their environment.	A B C D E

PART C

Your answers to questions 52-71 will help us determine what you think of the module in general. Please use this key:

A = Yes (or I agree) B = I'm not sure C = No (or I disagree)

52. I think we had to go through this module too fast. A B C
+B-

53. I think our class discussions were interesting and informative. A B C
+B-

54. I think our substitute teacher was adequately prepared to present the material. (Mark D if you had no substitute.) A B C
+B-

55. My teacher helped answer most of my questions about ideas presented in this module. A B C
+B-

56. I think we used the self-test questions in a way that helped me learn and think. A B C
+B-

57. We discussed the films in a way that helped each of us learn and think. A B C
+B-

58. I think my teacher enjoyed teaching this module. A B C
+B-

59. I think most other students enjoyed studying this module. A B C
+B-

60. Most of the necessary papers and supplies were ready when we needed them. A B C
+B-

61. I think that most of the questions asked by this test were fair. A B C
+B-

62. I think the papers in this module contain useful and interesting information. A B C
+B-

63. I think the papers in the module could be easily read. A B C
+B-

64. I think the ideas covered in this module fit together pretty well. A B C
+B-

65. The films used in the module were interesting and useful. A B C
+B-

66. I enjoyed taking the trip, and I learned a lot. A B C
+B-

67. The trip leaders did a good job helping me learn on the trip. A B C
+B-

68. I discussed some of the things in this module with my family or friends. A B C
+B-

69. I think the activities and exercises in this module were interesting and useful. A B C
+B-

70. Overall, I think this module was well worth the time we spent studying it in class. A B C
+B-

71. I would like to study other modules developed by the Environmental Education Project. A B C
+B-

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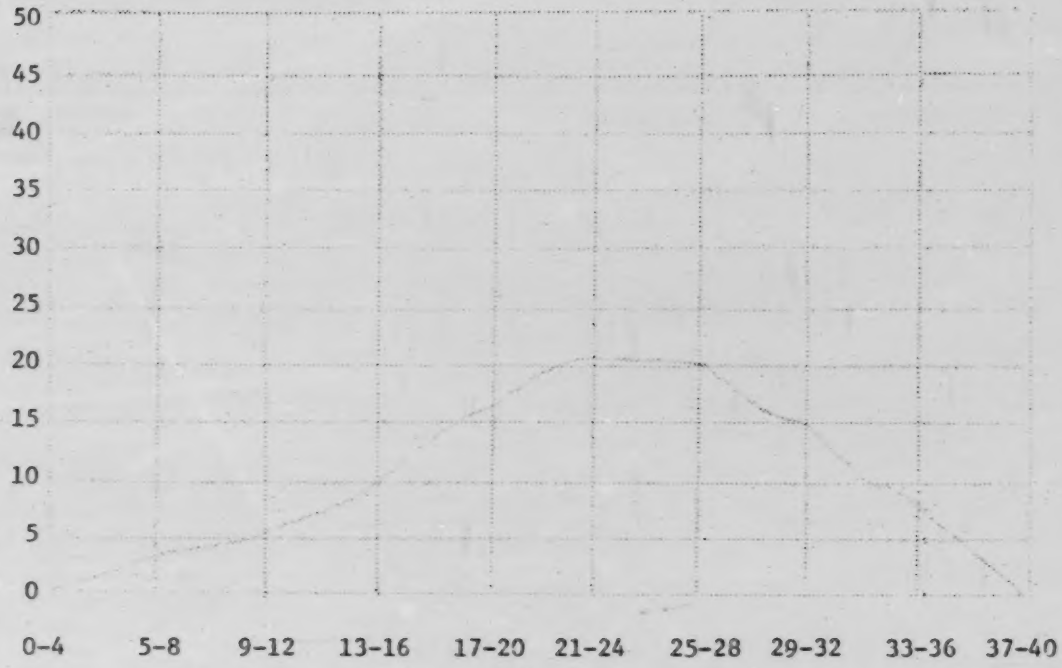
Percent of students answering the least answered attitude question_____.

Percent of students using patterned responses on the attitude questions_____.

Class Mean_____ Standard Deviation_____

Frequency Polygon (--- = pre; —— = post; ..... = 1972-73 composite post profile)



WHY DO ROBINS LAY BLUE EGGS?

Most birds that have open nests lay eggs that are white with brown specks. Such eggs are camouflaged and hard to see. Brown speckled eggs lying together in a nest blend into each other, and at a distance are not easily recognized as eggs.

Birds with open nests lay such camouflaged eggs because their biggest problem is nest predation. Most open nests of all species are lost to predators, and some of the predators (Jays especially) find the nest by spotting it. By laying camouflaged eggs, the nest is just a little more difficult to find and nest predation is reduced a little.

So, why do Robins and some other birds lay blue eggs? The answer is not known, but a good working hypothesis has been developed, in part by Dr. Stephen Rothstein. This hypothesis involved the Cowbird. Cowbirds are nest parasites, lay their eggs in other birds' nests, and let other birds raise their (the Cowbirds') young. We reason that Cowbirds in North America had their initial success in nests found in marshes. The host species there were probably Redwing Blackbird, Grackle, Robin, or Catbird. But, as time passed, a parent bird (such as a Robin) happened to have an instinctive or genetically based urge to toss the parasite's egg out of its nest, and so raised only its own young that year. This parent Robin raised more (or fatter) young than its neighbor. Its young also tossed out Cowbird eggs, and they too raised more young. Its descendants, in fact, filled the land, and crowded out the old Robins, which had accepted Cowbird eggs.

In the past, we presume that Robins laid speckled eggs, like Cowbirds, and like some of the other woodland thrushes. But in the family of egg tossers, those parents which laid eggs which were different from the Cowbird could more easily toss out the stranger. And, just as the egg tosser line of Robins crowded out the old stock by natural selection, those that laid odd eggs began also to leave more young, and so crowded out their brethren that were laying speckled, Cowbird-like eggs. Well, the hypothesis goes on. We assume that the eggs laid by these Robins were bluish and more or less free of speckles. And the bluer the egg laid, and the freer of speckles, the more easily it could be distinguished from speckled Cowbird eggs, which were then tossed out. So, egg type crowded out egg type in the Robin species until the only Robins left lay Robin's egg blue eggs.

Now the Cowbirds also were undergoing a process of natural selection. Robins were not the only species with acceptable nests for Cowbird eggs, and when a Cowbird avoided laying her eggs in a Robin's nest with blue eggs the Cowbird was more successful. That is, genetically different Cowbirds that avoided nests with blue eggs came into being, and left so many descendants that other Cowbird types were crowded out. Eventually, all the Cowbirds avoided laying their eggs in nests with blue eggs and chose the nests of other birds that still laid speckled eggs.

Other birds also had the problem of Cowbird nest parasitism. But they have tried to solve it in a slightly different way. Because the Robin laid blue eggs and tossed out Cowbird eggs, Cowbirds avoided nests with blue eggs. So, individuals of other species of birds that laid blue eggs were also avoided by Cowbirds. Thus, the birds laying blue eggs left more young, and crowded out the speckled egg layers of their species. The result was that there came to be many other species laying blue eggs, imitating Robins, but not usually tossing out strange eggs. The Dickcissel may be an example of this sort of evolution. Cowbirds frequently parasitize Dickcissel nests, but we suspect that this occurs because there are not enough alternative hosts available with speckled eggs, like Grasshopper Sparrows.

WHY DO ROBINS LAY BLUE EGGS? (Continued)

This is only a current working hypothesis, but it may well be true, and is interesting in any case. Robins, Catbirds, Grackles, all toss out Cowbird eggs, and lay blue eggs themselves (the Grackle eggs have black streaks as well). Dickcissels, Indigo Buntings, Redwing Blackbirds, Blue Grosbeaks and Lark Buntings all lay blue eggs, but sometimes accept Cowbird eggs.

Now I think this is a neat hypothesis, and is worth studying just because it is interesting. But it also bears directly on some major bird population problems. The Kirtland's Warbler in Michigan is in real trouble, and may be headed for extinction, due to Cowbird parasitism. The Dickcissel, as I will describe later, also is seriously and adversely affected by Cowbirds, and has already shown some local extinctions.

We are now proceeding as follows: If you hypothesis is true, we predict that Robins will toss out Speckled eggs, but not blue ones. We also predict that Cowbirds, when given a choice, will select speckled egg species to parasitize, avoiding blue egg species. For example, where Dickcissels (blue egg) and Grasshopper Sparrows (speckled eggs) nest together, the Grasshopper Sparrows will be more parasitized than the Dickcissel. Dickcissels will be parasitized only where they nest alone, and Cowbirds have no choice.

Reprinted from the BIRD POPULATIONS INSTITUTE Newsletter, Volume I, Number I, January, 1973.

SAFETY IN NUMBERS

Many species of American birds were heavily exploited in the last century. Market hunters would kill large numbers of certain species and ship them off to the cities to sell. This caused many species to become scarce. Fortunately, most of the species survived this exploitation. With governmental protection, many of these species recovered or at least did not continue their population declines. However, some species went extinct. Market hunting is only one way in which a species becomes rare. Destroying the habitat of a species can have the same effect.

Some species when they become sparse, proceed directly to extinction. Other species tolerate rarity, and when protected from hunters, are able to recover or presist indefinitely. What is the difference between these species?

The Passenger Pigeon, now extinct, is a good example of a species which was vulnerable when its numbers were sparse. Once they traveled about in enormous flocks searching for beech or oak forests that had recently dropped many beech-nuts or acorns. In these forests, the pigeons would nest in incredibly dense colonies and rear millions of fat squabs. When the squabs were grown, but still quite vulnerable, they would be left to their own devices on the forest floor, presumably to mature to a flying stage while feeding themselves on nuts. We suppose that most did mature and the population was replenished.

Imagine the squabs floundering in the beech forests. They must have been vulnerable prey: they were easy to find, easier to catch. Why did not the raccoons, opossums, owls and other predators eat all the squabs? Nobody knows for certain but we can make a good guess. Recall that the number of squabs involved was very large. A given forest had thousands of pigeons for every possible predator in the area. It is likely that the squabs were vulnerable for only a few weeks. How many squabs can a horned owl or raccoon eat in two weeks? One hundred? Five hundred? Even if he only ate the brains of his prey, a given predator would kill only a very small fraction of all the pigeon squabs available to him, perhaps 500 out of 40,000.

When Man entered the beech and oak forests and collected squabs for his cities in the hundreds of thousands, the Passenger Pigeon became sparse. And when sparse, the fate of the abandoned squabs was more precarious. When the pigeons were abundant, they could hide their vulnerability in their numbers: when sparse, they had no such protection. Before Man's predation, there were perhaps 50,000 squabs per raccoon; after there may have been only 50. In two weeks, a raccoon could easily catch all the remaining squabs. This may be the reason we lost a remarkable species.

Contrast the Passenger Pigeon with the Ivory-Billed Woodpecker. The Ivory-Bill was once widespread, and in total numbers perhaps constituted a substantial population. But it never achieved the densities that the Passenger Pigeon required for existence. Ivory-Bills have been reduced in range and probably in density by the destruction of their habitat but instead of quickly going extinct, remnant populations have persisted. It seems as if the Ivory-Billed Woodpecker's resistance to population decline is enhanced by being rare. These great woodpeckers probably do not depend on great numbers of other members of their species to survive as did the Passenger Pigeon.

Reprinted from the BIRD POPULATIONS INSTITUTE Newsletter, Volume I, Number 3, March, 1973.

Introduction

The Environmental Education Project was created by the Topeka School Systems to help you learn about your environment. The project develops and tests materials for classroom and field trip activities. This module focuses on life - yours and the world around you.

Most study of the biological sciences includes material about fossils, DNA, species, adaptations, populations, and succession. Each of these things, taken separately, tells only a little about life as we know it today. This module will try to fit these pieces together to make a better picture of life on earth - its history and its future.

The module reviews some of the answers to these questions:

1) How has life changed on this planet?
2) Why do animals and plants live where they do?
3) What causes animal and plant populations to change?
4) How is man changing the world around him?
5) What future awaits us?

You will use films, papers, and a field trip to the University of Kansas Natural History Museum to answer these questions.

TESTS

The Environmental Education Project, which developed this module, uses test results to determine what you learned from the module and what you think about different parts of it. You will be given tests over the module before and after you study it. The tests will be used to determine what changes should be made in the material. Whether or not the teacher grades you using these test results is a decision to be made by your teacher.

Test questions will be drawn from the field trip work sheet and the student self-test questions on each paper.

All of your answers on test questions about factual material will be reported to your teacher. The test will also contain a set of questions about your opinions of the materials used in the module. Your answers to these questions will be used by the Environmental Education staff to improve the material you are studying.

Green pages in the teacher's material usually will contain three sections:

1) "Topics and Concepts" - lists the ideas from the student papers and exercises that will be on the final test. The numbers of the topics correspond with the behavioral objectives listed in the front portion of this module.

2) "Teacher Suggestions" - provides background material and suggestions for presenting the paper or exercise.

3) "Answers to Student Self-Test Questions" - provides answers and follow-up material to help in a discussion and review of the self-test.

This introductory paper is concerned with the following three attitudes. They will be nurtured throughout the next three weeks as the students work with this module.

TOPICS AND CONCEPTS TESTED

1) Students should read each opinion question on the final test and try to respond truthfully.

2) Upon completion of this module, students should indicate a desire to study other modules developed by the Environmental Education Project.

3) Upon completion of this module, students should indicate a desire to study more material about man's relationship to his environment.

TEACHER SUGGESTIONS

Please bring out three points during the introduction:

1) Too often genetics, paleontology, biomes, food webs, and evolution all appear unrelated to each other and to life as students see it. This module provides a quick overview of these topics and points out many practical applications of some of these most basic biological concepts. It is a module for average or above students who are willing to consider ideas, as well as facts.

2) The project is very interested in student and teacher opinions, criticisms, and compliments. We get these comments during the field trip, from teachers' verbal and written comments, and from opinion questions on the student test. Please encourage students to react to the material being presented. Pass their reactions and yours on to us.

3) You should make it clear if students will be graded using the factual part of the posttest. The tests are fair and are strictly based on the behavioral objectives included in this module. If the students understand each paper's student self-test questions and field trip material, they should do very well on the posttest.

Time, Lines and Events

A calendar is a time line. Washington's birthday appears near the beginning of the time line, July 4 in the middle, and Christmas near the end. Time lines are useful for organizing different events into sequence. When more accuracy is needed, the time line may be magnified to look at just one part. For instance, knowing that you have a dentist's appointment on March 10 really is not accurate enough. We magnify that day into a time line with 24 hours, and magnify each hour to include 60 minutes. Then we can indicate that the appointment is at 10:45, March 10.

If the time line of the world was condensed onto a year calendar, with January 1 the beginning of the world, very primitive life would first appear in August, dinosaurs would appear December 17 and disappear December 26, and man would make the scene just before midnight, December 31.

The film, "Time: Lines and Events," shows how time lines can be used to understand the history of our world. The film uses a time line of years to discuss the age of the earth, of primitive plants and animals, of dinosaurs, and of man. It does not explain how these ages are determined. Read Paper C, "Radioactive Dating," if you wish to learn how ages of rocks and fossils are measured.

STUDENT SELF-TEST

1) Use the time line below and indicate: (1) when the first signs of life appeared on earth, and (2) when the early signs of corals, jellyfish, and other simple animals appeared.

BILLIONS of years 5 — 4 — 3 — 2 — 1 — Now

2) On the time line used in question 1, indicate when most dinosaurs were alive.

3) What was the world like at the beginning of the time line in question 1?

4) Use the new time line below to show when dinosaurs were common and when men first appeared on earth.

MILLIONS of years 300 — 200 — 100 — 80 — 60 — 40 — 20 — Now

5) What do you think was living on land at the beginning of the time line in question number 4? Give your best guess.

6) Most of the fossils left by early man could be located somewhere on the time line below. Indicate on this line when fossil skeletons very much like our own first appeared.

THOUSANDS of years 500 — 400 — 300 — 200 — 100 — 50 — Now

7) If the time line in question 6 was half a foot long, how long would it need to extend to include the history of dinosaurs (200 million years ago)? How long would it need to be to include the history of our earth (5 billion years ago)?

Behavioral Objective Numbers	Topics and Concepts
4	Students shall be able to select a time line of the earth showing the relative positions of dinosaurs and primitive ocean life.
5	Students shall be able to select the correct relationship between the span of man's existence and that of the world.
6	Students shall be able to select the best method for accurately measuring the age of a fossil.
7.	Students shall indicate that climates and land forms undergo continuous modification over long periods of time.
35	Students shall select the class of modern animals most like the first vertebrates that left fossil remains.

Teacher Suggestions

Duplicate page B-3 and give copies to each student before using the film.

Before showing the film, place this chart on the chalk board.

	First Evidence of Existence
Primitive Algae	
Coral, Jellyfish, Trilobites	
Dinosaurs in water	
Peak dinosaur population	
Most dinosaurs extinct	
Neanderthal Man	
Cro-Magnon Man	
First pyramids	

Show the film until the time two billion years ago has been discussed. Stop the film. Ask the review questions below.

1) When did the first algae appear?

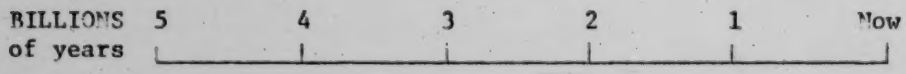
Answer:
Fill in the time in full on the chart. (2,000,000,000 years)

2) What was the world doing during the previous 3 billion years?

Answer:
Cooling down, forming oceans, and accumulating organic chemicals produced by combinations of lightning, ultraviolet light, and the gases in our air.

STUDENT SELF-TEST

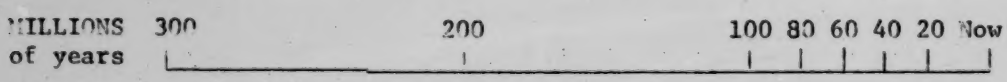
1) Use the time line below and indicate: (1) when the first signs of life appeared on earth, and (2) when the early signs of corals, jellyfish, and other simple animals appeared.



2) On the time line used in question 1, indicate when most dinosaurs were alive.

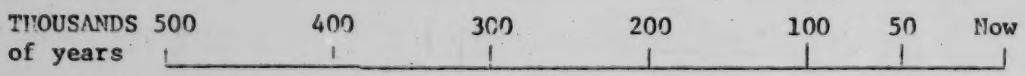
3) What was the world like at the beginning of the time line in question 1?

4) Use the new time line below to show when dinosaurs were common and when men first appeared on earth.



5) What do you think was living on land at the beginning of the time line in question number 4? Give your best guess.

6) Most of the fossils left by early man could be located somewhere on the time line below. Indicate on this line when fossil skeletons very much like our own first appeared.



7) If the time line in question 6 was half a foot long, how long would it need to extend to include the history of dinosaurs (200 million years ago)? How long would it need to be to include the history of our earth (5 billion years ago)?

Let the film run through the summary of man's history, then fill in these dates:

1) Neanderthal man appeared about 50,000 years ago.

2) Cro-Magnon man, who was very much like us, appeared during the last ice ages - between 20,000 and 30,000 years ago.

3) The first pyramids were built about 5,000 years ago.

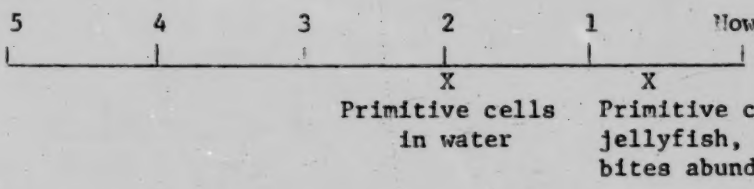
The rest of the film contains a one-minute summary of U. S. history, a population growth curve for mankind, and a general summary of the film. You may wish to turn off the sound and light, and run the film on through while students work on the student self-test with this film.

Answers - Student Self-Test Questions

Ask each student to answer these questions on the separate sheet of paper, then grade them in class. These may be easily graded in class if you make the three time lines on the board, and fill in pertinent points as shown in the answers below.

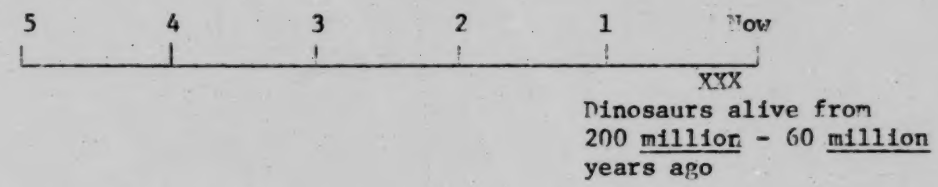
Q 1. Use the time line below and indicate: 1) when the first signs of life appeared on earth, and 2) when the early signs of corals, jellyfish, and other simple animals appeared.

A



Q 2. On the time line used in question 1, indicate when most dinosaurs were alive.

A

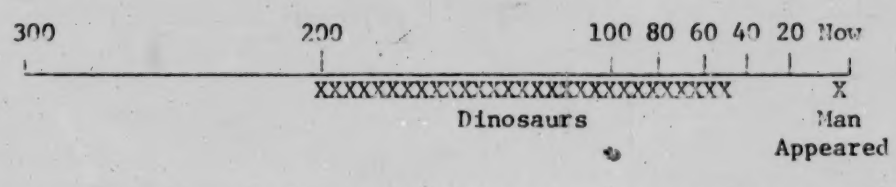


Q 3. What was the world like at the beginning of the time line in question 1?

A The world was a vast collection of molten rock and gases.

Q 4. Use the time line below to show when dinosaurs were common and when men first appeared on earth.

A



Note that the exact times vary from book to book. These times are listed according to the film. Most recent texts show dinosaurs becoming common about 225 million years ago.

Q 5. What do you think was living on land at the beginning of the time line in question number 4? Give your best guess.

A Land plants were common 300 million years ago. Primitive amphibians and small reptiles were beginning to move onto land.

NOTE - The answer to this question was not given in the film - it is a question to encourage students to think and to note the differences between time lines.

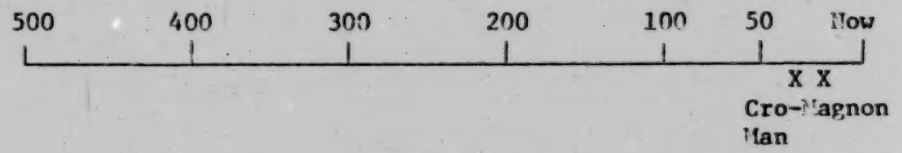
Use this opportunity to point out that dinosaurs (and other organisms) do not appear spontaneously, but have ancestors. Dinosaur ancestors include the primitive amphibian which lived 300 million years ago and primitive fish, which trace their origin back 500 million years.

If students question how life began, refer them to the works of A. I. Oparin and Stanley Miller. Brief descriptions of the conditions required for abiogenesis are contained in most biology text books.

If students ask how the ages of fossils are determined, use the opportunity to introduce Paper C, "Radioactive Dating."

Q 6. Most of the fossils left by early man could be located somewhere on the time line below. Indicate on this line when fossil skeletons very much like our own first appeared.

A



Q 7. If the time line in question 6 was half a foot long, how long would it need to extend to include the history of dinosaurs (200 million years ago)? How long would it need to be to include the history of our earth (5 billion years ago)?

A 200 feet (one-half million = one-half foot, 200 million = 200 feet) for the history of dinosaurs.

5,000 feet (one-half million = one-half foot, 5 billion = 5,000 million) for the history of our earth.

In other words, human history occupies less than one inch of a time line nearly one mile long for the earth.

Radioactive Dating (Optional)

Materials are radioactive if their atoms break up and release radioactive particles, such as alpha and beta rays. All rocks (and you, for that matter) contain small amounts of several different kinds of radioactive chemicals. Newly formed rocks and living bodies contain more radioactive atoms than old rocks and fossils. This happens because the radioactive atoms gradually break up and leave behind smaller atoms which are not radioactive. The ages of most important fossils and rocks are measured by comparing the amounts of certain radioactive and nonradioactive chemicals in the fossil or rock.

Radioactive materials contain atoms which break up at a steady rate. For instance, one pound of carbon 14 would turn into one-half pound of carbon 14 after only 5,730 years. One pound of pottassium 40 would become one-half pound in 1.3 billion years. Every radioactive material breaks up at a steady and measurable rate. Each radioactive atom that breaks up produces a radioactive ray that machines, such as a geiger counter, can detect. Since a pound of any chemical contains over a trillion billion atoms, the radioactivity of even materials which break up very, very slowly can be measured, for at least a few of the trillions of atoms will split and release a radioactive ray.

The age of rocks over a billion years old can be measured by comparing the amount of potassium 40 with the chemical it will become when it breaks up - argon 40. Argon is a very rare gas which would not normally be found in rocks. Potassium is a chemical that is usually found in rocks. If equal amounts of potassium 40 and argon 40 are found in a rock, then the rock must be about 1.3 billion years old, since half of its potassium 40 has broken up to produce argon 40. If more, or less argon 40 is present, the age can be calculated from the ratio of pottassium to argon.

Rocks less than 70,000 years old can be dated by measuring the amount of radioactive carbon 14 and comparing it with the quantity of carbon 12 in the rock. Newer rocks have more radioactive carbon 14. Rocks of other ages can be dated using other radioactive elements, such as uranium 234, beryllium-10, and so on.

As scientists have created better machines for measuring exact amounts of different chemicals, the ages of rocks and fossils have become more accurate. Dates measured today are much more accurate than many determined just 10 years ago, and we will continue to improve our knowledge for years to come.

STUDENT SELF-TEST

1) What radioactive chemical would you use to measure the age of very, very old rocks?

2) What radioactive chemical would you use to measure the age of a mummy in a pyramid?

3) Would old or new rocks produced by volcanoes have more argon 40?

Behavioral Objective Number

Topics and Concepts

6 Students should be able to select the best method for measuring the age of a fossil.

Teacher Suggestions

Use this paper as a quick review of radioactive dating procedures if you wish.

If the class discusses the Self-Test Questions, and you field their questions about radioactive dating, the behavioral objective should be met.

Answers - Student Self-Test Questions

Q 1. What radioactive chemicals would you use to measure the age of very, very old rocks?

A Potassium 40 content would be the radioactive material of choice.

Q 2. What radioactive chemical would you use to measure the age of a mummy in a pyramid?

A Carbon 14 could give a good age at this time period (5,000 years ago).

Q 3. Would old or new rocks produced by volcanoes have more argon 40?

A Old rocks should have more argon 40, since their potassium 40 would have decayed to a much larger extent, trapping argon 40 in the rocks. Argon 40 produced in the earth's core would be lost from molten lava when exposed to air, leaving little argon 40 in new volcanic rocks.

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The Changing Earth

This paper will discuss changes in North America's land, animals, and plants during the last 600 million years. On a time line of the earth's history, 600 million years is not very long, but most changes in plant and animal life occurred during this time. As this period begins, there are no animals with backbones and no land plants in the world.

Cambrian Period

During the Cambrian period, 600 million years ago, there were no land plants or animals (at least we can find no fossil evidence of their existence).

The oceans had abundant life and fossil remains of algae, corals, jellyfish, and trilobites were common. By carefully marking the location of rocks containing Cambrian fossils, men have constructed a map of North America as it probably looked 600 million years ago.

During the next 100 million years, these land forms would change drastically as the continent produced new mountains, and massive areas of land changed elevation.

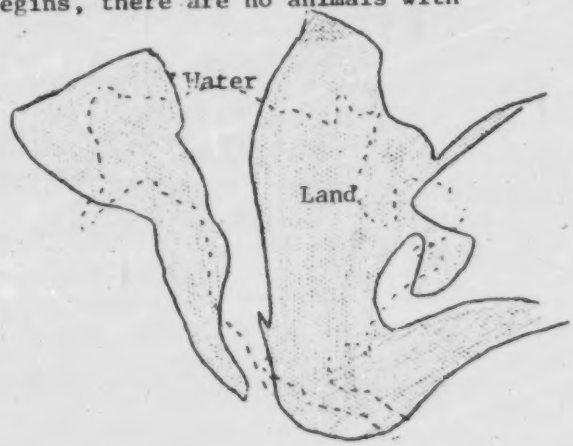

Figure 1. North American land Boundaries during Early Cambrian. (The dotted outline indicates present North American boundaries.)

Ordovician Period
(500 Million Years Ago)

Fossils found in rocks from the Ordovician Period indicate that very primitive land plants may have appeared along the oceans' edge. However, nearly all life of this period was still found in the oceans. Algae were beginning to take complicated forms, and the first very primitive fish were appearing.

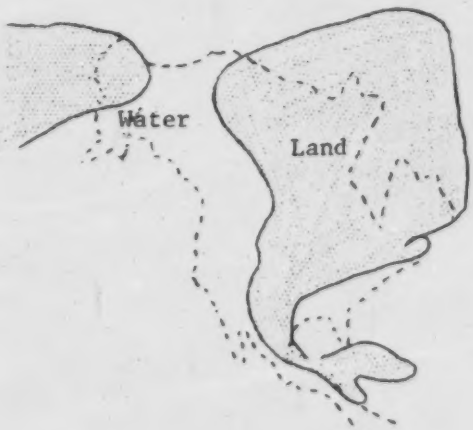

Figure 2. North American Boundaries 500 million years ago.

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Silurian and Devonian Periods
(400 Million Years Ago)

During the next 100 million years, North America continued to change its ocean boundaries, as land further to the north rose in relation to the land to the south. The climate of this land was much warmer then than now. Many scientists feel that the North Pole of today must have faced the sun more directly then, so that the climate in the northern hemisphere was warmer.

In any case, during this time the oceans produced sharks, new kinds of algae, and sea lilies. On land, amphibians, trees with cones (conifers), and insects were leaving increasing numbers of fossils.

Figure 3. North American Boundaries 400 Million Years Ago

Mississippian and Pennsylvanian Periods
(300 Million Years Ago)

The Mississippian and Pennsylvanian Periods found tremendous swamps of conifer trees, mosses, insects, amphibians, and early reptiles. During this time, the Pennsylvania coal beds were formed, and plants that would produce our oil were being buried under water. Most of the available land area was filled with forests.

The ocean continued to be populated with sharks, primitive fish, sea lilies, and trilobites much like those found 300 million years earlier.

The limestone rocks in eastern Kansas were deposited during these periods.

Figure 4. North American Boundaries 300 Million Years Ago

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Permian and Triassic Periods
(200 Million Years Ago)

During the next 100 million years, the climate of the northern hemisphere continued to be warmer and moister than today.

A land bridge connected the North American and European continents during this time. Plants and animals from both continents used this bridge to reach new lands. These invasions led to the extinction of many primitive plants, insects, and amphibians by fitter species that had developed in other lands.

Early reptiles were becoming more common, particularily the swimming reptiles, which left many fossils. Conifer trees, with cones much like evergreens today, were becoming the dominant tree throughout the land.

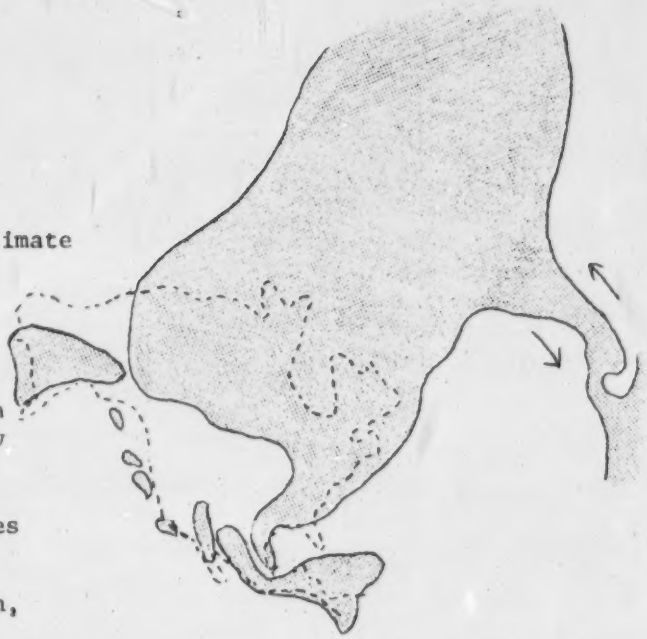

Figure 5. North American Boundaries
200 Million Years Ago

Jurassic and Early Cretaceous Periods
(100 Million Years Ago)

Our continent was divided by the ocean during the next 100 million years. The western portion was connected to Asia by a land bridge, the eastern portion extended far to the east, but was separated from Europe during most of the 100 million years.

During this time the first flowering seed plants developed, the forests of conifers shrunk, dinosaurs became the dominant land animals, but primitive birds and mammals were appearing. Rocks from these time periods indicate that our continent had a great variety of plants, animals, and landscapes.

Figure 6. North American Boundaries
100 Million Years Ago

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Late Cretaceous and Tertiary Periods
(100 Million to 2 Million Years Ago)

The climate of North America has cooled during the last 100 million years. Nearly all animals and plants of the earlier periods became extinct. Mammals and birds, much like those today, adapted to the changing climate and helped eliminate the dinosaurs. As the two parts of North America were rejoined, many kinds of animals and plants from both parts lost the battle for survival. In short, this period saw much upheaval and chaos as climate, landscape, plants, and animals changed drastically in only 98 million years.

Quaternary Period
(2 Million Years to Now)

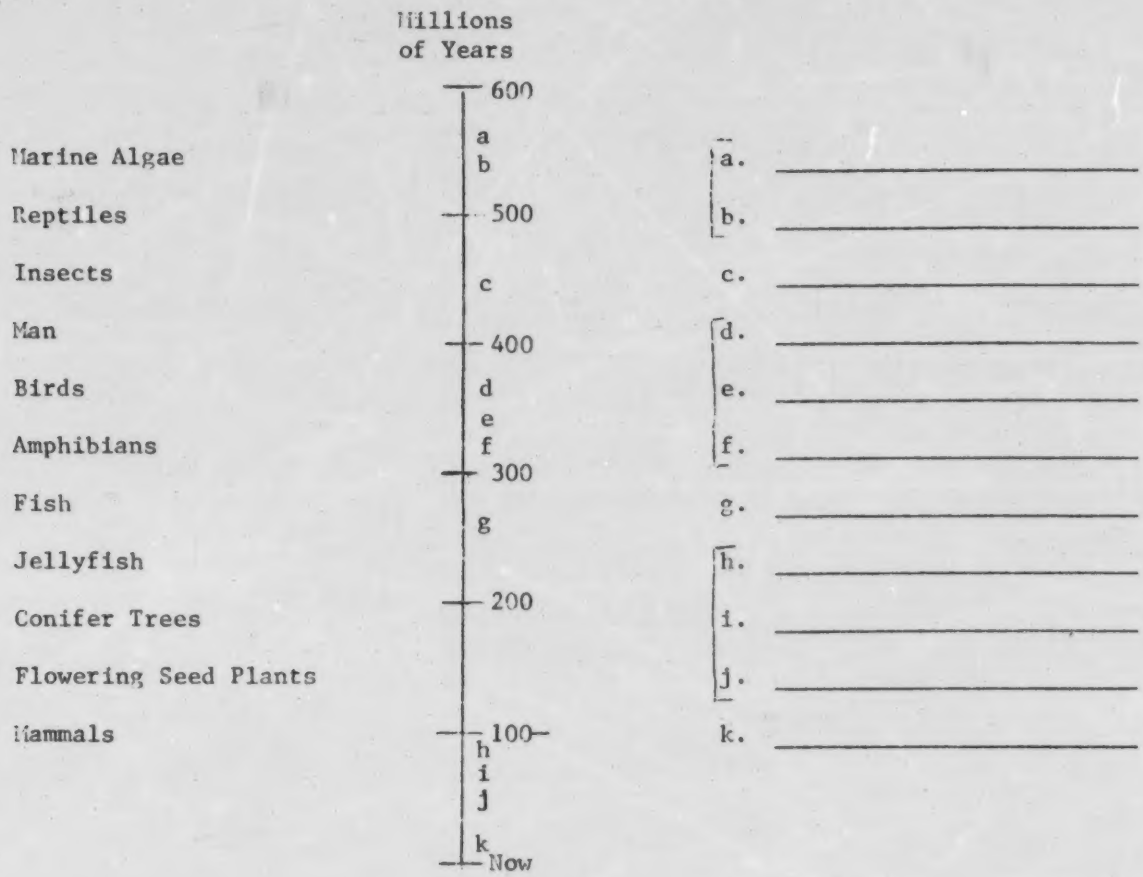
The final period in the earth's geologic clock is the Quaternary. It has barely begun, but change has happened at an ever-quickening pace. The ice ages began and retreated only 10,000 years ago. Land bridges between North and South America caused thousands of species of primitive South American animals to die as more advanced animals from the north moved south below the glaciers. A new mammal, man, appeared during the last half-million years. This new species has turned forests and deserts to prairies, and nearly every plant and animal still living is being tested, examined, encouraged, or discouraged by this new mammal.

STUDENT SELF-TEST

1) Over the last 600 million years, which of the points on the map of the North American continent would have been under water the most? Which one would have been under water the least?

2) List at least two ways that changing land elevations have affected the plants and animals living on our continent.

3) Match the plants and animals with the appearance of their first fossils on the time line below. The letters on the time line indicate when a new plant or animal appeared.



4) Over the last 400 million years, there have been thousands of species of amphibians and conifer trees. What has happened to most of those species?

Behavioral Objective Number	Topics and Concepts
4	Students shall select a time line of the earth showing the relative positions of dinosaurs and primitive ocean life.
5	Students shall select the correct relationship between the duration of man's existence and that of the world.
7	Students should indicate that climates and land forms undergo continuous but slow modification.
8	Given a hypothetical problem, students should indicate that the populations of animals and plants on either side of a new land bridge will undergo change.
9	Students shall be able to select the sequence of appearance for classes of the vertebrate animals.
10	Students shall be able to apply the concept "the normal fate for most species is extinction," to a particular problem.
11	Given a series of graphs, students shall be able to select the one indicating an increasing diversity of animal and plant species in the world in recent eras.

Teacher Suggestions

Use this paper in conjunction with the film "Earth Science: Parade of Ancient Life." Use, but do not stress, the names of the periods as you discuss the changes with the class. The topics above indicate the primary thrust of this paper.

Answers - Student Self-Test Questions

Q 1. Over the last 600 million years, which of the points on the map of the North American continent would have been under water the most? Which one would have been under water the least?

A Point two, over the Rocky Mountains and Western Kansas, has been below sea level much of the last 600 million years.

Point one, in upper Canada, has been above sea level most of the last 600 million years.

Points three and four have had varied histories of submergence and emergence from our oceans.

Q 2. List at least two ways that changing land elevations have affected the plants and animals living on our continent.

A 1) Increasing elevations have changed climates, which have placed stress on animal and plant populations. Mountains cause changing wind and moisture patterns in surrounding lands and can place barriers to seasonal migration. These changes in weather and migration will isolate some animals from others and may cause new species to develop and old ones to die.

2) Land bridges formed between isolated bodies of land will drastically affect plants and animals on both sides of the bridge. As organisms with strong adaptive advantages from one area enter a new area, they may undergo a population explosion due to rich, new food supplies and lack of effective native predators.

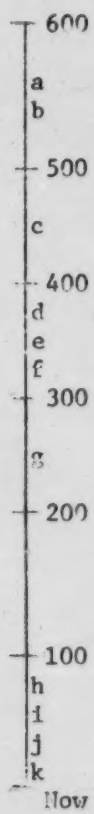
The shifting ocean floor has created and broken land bridges between North America and Europe, Asia, and South America. In comparatively recent times, mammals from North America caused the extinction of many marsupials in South America. Within the last 20,000 years humans crossed into North America and promptly encouraged the extinction of elephants, giant bison, and horses in North America.

The population explosions of Starlings, House Sparrows, and Gypsy Moths are examples of animals brought to the United States by an artificial land bridge (man's ships). A natural land bridge between Africa and Australia would probably cause the elinination of almost all marsupials in Australia.

Q 3. Match the times that animals and plants first appeared with the letters on the time line below.

A

a. Marine Algae
b. Jellyfish
c. Fish
d. Amphibians
e. Insects
f. Conifer Trees
g. Reptiles
h. Birds
i. Mammals
j. Flowering Seed Plants
k. Man



NOTE: The bracketed sets of animals and plants appeared in about the same period of time, so students should not be expected to differentiate the sequence within brackets.

NOTE: Remind students that this time line represents only last 1/8th of the world's total time line. If the time line of the earth was one year long this chart would only cover the period from November 17 to December 31.

Q 4. Over the last 400 million years, there have been thousands of species of amphibians and conifer trees. What has happened to most of those species?

A Most species have become extinct, either because they were unable to adapt and died, or they did adapt and became a new species.

NOTE: Many students regard extinction as meaning that the last animal of the species dies and leaves no offspring. This is, of course, true for some animals and plants such as most dinosaurs, the passenger pigeon and the dodo bird.

The much more common case is that the species change so much that scientists call it a new species. Students are familiar with the continuous appearance of new "strains" of flu viruses. These new strains could be called new species, in that their characteristics are quite different from the parent strain.

We have had ever increasing numbers of species appear as older species developed into several species in different areas. This topic will be developed in more depth with Paper H.

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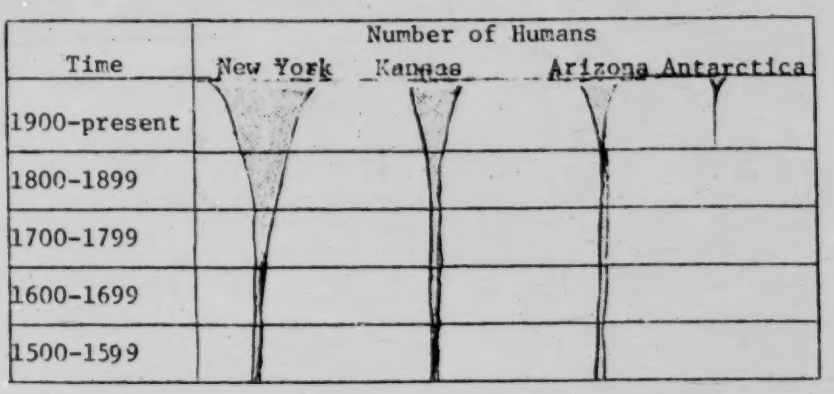
The Parade of Ancient Life

Paper D, "Changing Earth," gave a quick summary of how land, animal, and plant forms changed as the earth moved through its most recent periods. The film, Earth Science: Parade of Ancient Life," illustrates the changes in living organisms in more detail.

A new type of graph will be used in this film, and a quick explanation may help you understand the film and the questions which follow.

The width of each of the shaded areas on the graph to the right indicates the number of humans alive during each period of time. The wider areas have more humans. In Antarctic, humans only recently arrived and stayed.



Graphs of different animal and plant species can also be made, with eras and periods on the verticle scale, and the varying number of living species on the horizontal scale. Notice that, just as different humans live in different centuries, very different species also live and die as time moves along.

STUDENT SELF-TEST

1. On a copy of the chart below, draw and label graphs to indicate the number of species of living organisms during the different eras for dinosaurs, mammals, flowering plants, and conifer plants. Paper D, and the graph on question 2, should help you answer this question. A graph of the bird population is given as an example.

Millions of Years Since Period Began	Era	Period	Number of Species of Living Organisms
2	Cenozoic	Quaternary	Birds
70		Tertiary	
130	Mesozoic	Cretaceous	
175		Jurassic	
225		Triassic	
245	Paleozoic	Permian	
305		Pennsylvanian	
350		Mississippian	
410		Devonian	
430		Silurian	
500		Ordovician	
600		Cambrian	

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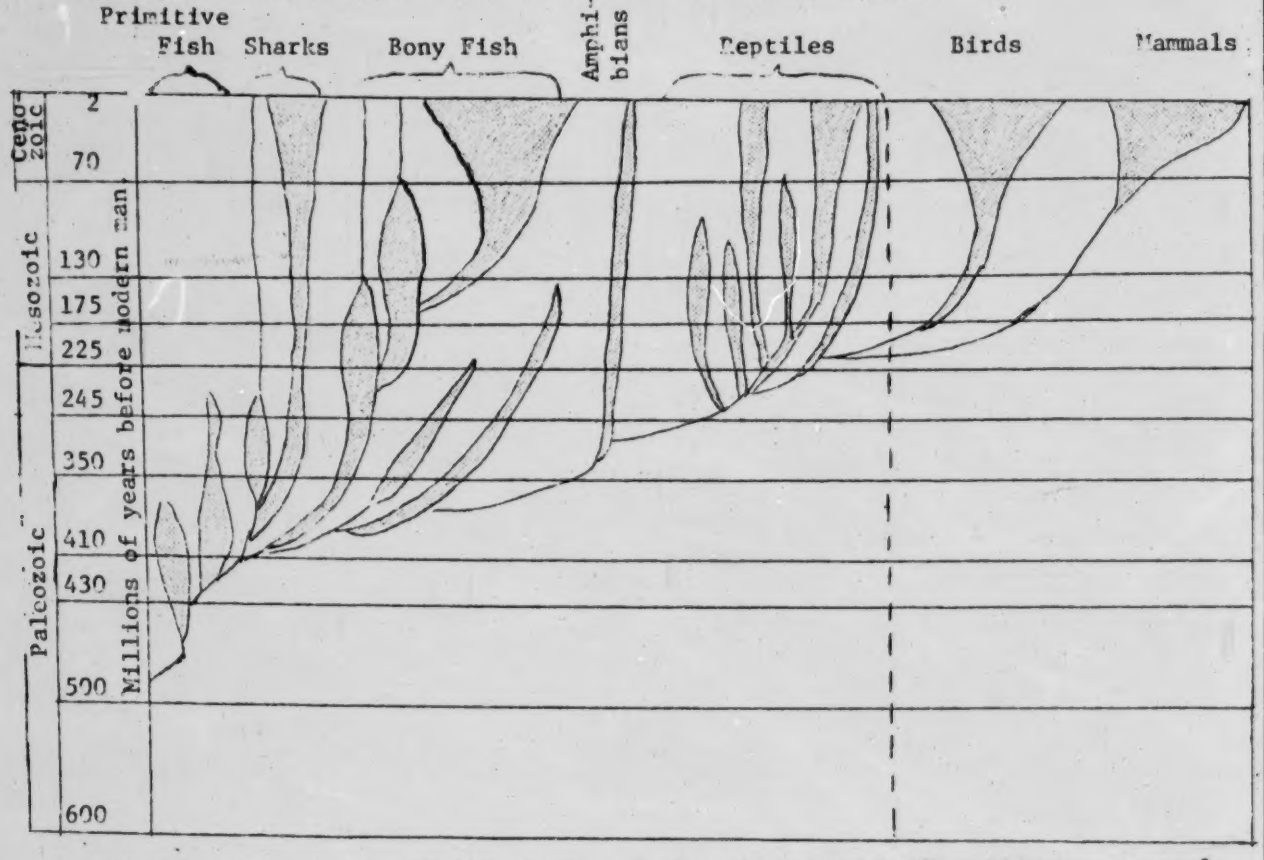
The chart below shows three things: 1) the relationships between different classes of backboned animals, 2) the relative population sizes of the classes, and 3) the times that animals in the classes became common.



2. What has happened to 99.99% of the species which lived 100 million years ago?

3. What three classes of animals showed the largest increase during the Cenozoic Era?

4. Fill in the diagram below to show the sequence of evolution for mammals, fish, amphibians, birds, and reptiles.

5. Which of the three eras had (or has) animals that show the greatest differences in body build, internal organs, reproduction methods, skin covering, and so on?

6. Why are fossils of land animals so rare?

7. Most of the energy found in the coal, oil, and gas used today was stored during which era? What organisms were responsible for making these fossil fuels?

8. The earth's timeline is shown below. Darken the portion of this timeline which corresponds to the time shown on the large chart above.

Millions of years

5,000 | 4,000 | 3,000 | 2,000 | 1,000 | 500 | now

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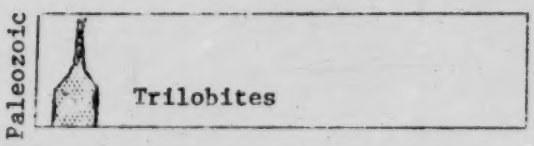
Behavioral Objective Number	Topics and Concepts
4	Students shall select a time line of the earth showing the relative positions of dinosaurs and primitive ocean life.
5	Students shall select the correct relationship between the duration of man's existence and that of the world.
9	Students shall be able to select the sequence of appearance for classes of the vertebrate animals.
10	Students shall be able to apply the concept "the normal fate for most species is extinction," to a particular problem.
11	Given a series of graphs, students shall be able to select the one indicating an increasing diversity of animal and plant species in recent eras.
12	Students shall indicate that many animal and plant species probably left no fossil record.
13	Students shall indicate that much of the energy we use today was stored millions of years ago by plants.
35	Students shall select the family of modern animals most like the first vertebrates that left fossil remains.

Teacher Suggestions

Before showing the film, have students read the introduction on Paper E. Discuss the interpretation of the multiple-population charts. Stress the relative, not absolute, nature of the widths used on the various graphs.

Begin showing the film Earth Science: Parade of Ancient Life, and allow it to run until the following chart for Trilobites first appears. Stop the film and ask the review questions below.



1. The film mentions that most fossils are found in sedimentary rocks. What are sedimentary rocks? Why are fossils located in them?

Answer: Sedimentary rocks are formed from sand, mud, or dead bodies of millions of small animals and plants. Fossils may be formed when an organism, or parts of an organism are buried in the sediments.

2. How many land animals living today will become fossils?

Answer: Very, very few. - Most animals are eaten and/or decayed before being buried by sediment.

3. Trilobites are Arthropods. What are Arthropods?

Answer: Segmented animals with hard exteriors, such as lobsters, crayfish, insects, centipedes, and spiders.

Student Self-Test

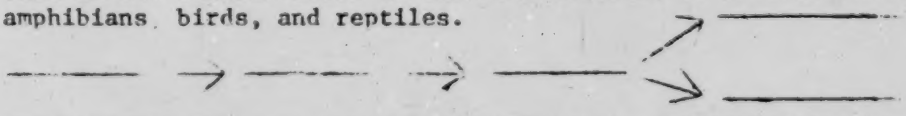
1. On a copy of the chart below, draw and label graphs to indicate the number of species of living organisms during the different eras for dinosaurs, mammals, flowering plants, and conifer plants. Paper D, and the graph on page E-2, should help you answer this question. A graph of the bird population is given as an example.

Millions of Years Since Period Began	Era	Period	Number of Species of Living Organisms
2	Cenozoic	Quaternary	Birds
70		Tertiary	
130	Mesozoic	Cretaceous	
175		Jurassic	
225		Triassic	
245	Paleozoic	Permian	
305		Pennsylvanian	
350		Mississippian	
410		Devonian	
430		Silurian	
500		Ordovician	
600		Cambrian	

2. What has happened to 99.99% of the species which lived 100 million years ago?

3. What three classes of animals showed the largest increase during the Cenozoic Era?

4. Fill in the diagram below to show the sequence of evolution for mammals, fish, amphibians, birds, and reptiles.



5. Which of the three eras had (or has) animals that show the greatest differences in body build, internal organs, reproduction methods, skin covering, and so on?

6. Why are fossils of land animals so rare?

7. Most of the energy found in the coal, oil, and gas used today was stored during which era? What organisms were responsible for making these fossil fuels?

8. The earth's time line is shown below. Darken the protion of this time line which corresponds to the time shown on the large chart above.

4. Point out the chart on question one in the student self-test for this paper. Ask the students to name the periods in the early part of the Paleozoic Era.

Answer: Devonian, Silurian, Ordovician, and Cambrian.

5. Turn on the projector, but use the "still" knob to hold the chart of the Trilobite population on the screen. Explain that the number of animals is based on estimates made from the number of fossils discovered in rocks of the various periods.

   Ask the question: "Would you find more Trilobites in the Ordovician or Pennsylvanian rocks?" Wait until students look up the answers so that they will become familiar with the lables of the various periods.

Answer: Ordovician

6. Before proceeding with the show, point out that the rocks around Topeka were deposited during the Pennsylvanian Period. The fossils which will be shown for the rest of the Paleozoic Era can be found in limestone around Topeka.

   NOTE: Running the film in reverse momentarily before continuing through the film will enable students to pick up the thrust of the film when it was stopped.

Stop the film when it begins to introduce the Mesozoic Era using the time line beginning 240 years ago and ending 70 million years ago.

Ask the students these questions:

1. How did the kinds of animals with backbones change during the Paleozoic Era?

Answer: Fish developed. Some of these fish developed lungs and primitive legs. From these fish, amphibians developed. At the end of the era, many fish, lung fish, and amphibians were living.

2. How did plant life change during this era?

Answer: Primitive algae developed into more complex seaweeds. Some of this seaweed developed the ability to live along the water's edge where they were alternately covered by water and air. By the end of the Paleozoic, some of these plants had developed into the dense evergreen swamps which made most of the coal and oil we use today.

3. How did plants of the Paleozoic Era influence the lives we lead today?

Answer: Coal, oil, and natural gas are all created from dead plant bodies from the Paleozoic Era.

4. Which of the organisms to be graphed on question one appeared during the Paleozoic Era?

Answer: Have students indicate that conifers appeared in the Devonian and their population swelled throughout the Paleozoic.

Stop the film after reaching the introduction to the Cenozoic Era. Ask these questions at this point.

1. How did backboned animals change during the Mesozoic Era?

Answer: Some amphibians developed into reptiles. Some reptiles developed into primitive birds and mammals. At the conclusion of this era, fish, amphibians, reptiles, mammals, and birds were all common.

2. What types of reptiles lived during the Mesozoic Era?

Answer: Dinosaurs lived on land and in the water. Some reptiles could fly. In addition, reptiles like those living today lived at this time. These included snakes, turtles, and crocodiles.

3. What changes occurred in plants during this era?

Answer: The evergreens were largely replaced by flowering plants by the end of the Mesozoic.

Finish the film, then use these questions to review the Cenozoic Era.

1. What changes occurred in backboned animals during the Cenozoic Era?

Answer: Most reptiles disappeared, modern birds and mammals appeared, and man appeared very late in the era. Although the film did not mention this, most modern bony fish first appeared during the Cenozoic.

2. What has happened to most species of animals and plants that have lived on earth?

Answer: Most species have either made such extensive adaptations that they became new species, or all members of the non-adapting species died. In either case, most species existing more than a million years ago are now extinct.

Filling out the worksheet: Encourage students to use Paper D and the chart on page E-2 to construct their best visualization of the increasing and decreasing plant and animal populations. This is the final paper dealing with paleontology, and every student should master its objectives.

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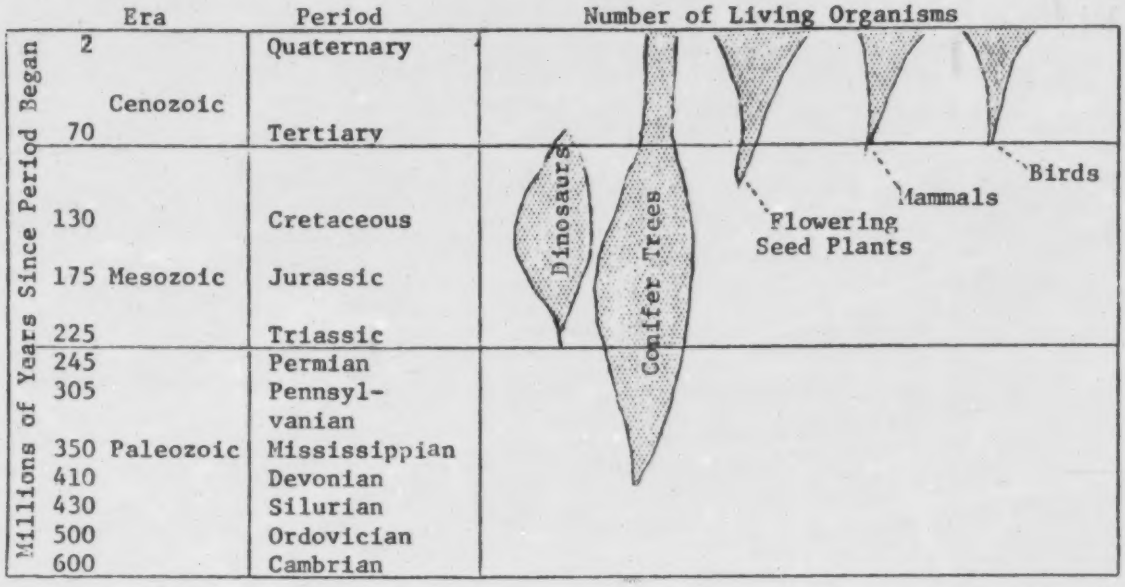
Answers - Student Self-Test Questions

Q 1. On a copy of the chart below, draw and label graphs to indicate the number of living organisms during the different eras for dinosaurs, mammals, flowering plants, and conifer plants. Paper D, and the graph on question 2, should help you answer this question. A graph of the bird population is given as an example.

A



Q 2. What happened to 99.99% of the species which lived 100 million years ago?

A Most species became extinct through failure to adapt to changing conditions or through successful but major adaptations which changed the species.

Q 3. What three classes of animals showed the largest increase during the Cenozoic Era?

A Birds, mammals, and bony fish.

Q 4. Fill in the diagram below to show the sequence of evolution for mammals, fish, amphibians, birds, and reptiles.

A Fish → Amphibians → Reptiles → Mammals
Reptiles → Birds

Q 5. Which of the three eras had (or has) animals that show the greatest differences in body build, internal organs, reproduction methods, skin covering, and so on?

A The Cenozoic Era has the most diverse group of animals. They range from the giant whale and monitor lizards to the smallest minnows, insects, and snails. Earlier eras may have had larger numbers of different kinds of reptiles, but these were still just reptiles. The Cenozoic has reptiles, plus a tremendous variety of birds, mammals, and the newly developed bony fish.

Q 6. Why are fossils of land animals so rare?

A These animals are almost always eaten, rather than being buried under mud or sand.

Q 7. Most of the energy found in the coal, oil, and gas used today was stored during which era? What organisms were responsible for making these fossil fuels?

A The Paleozoic Era was responsible for most of our coal, although the Mesozoic has produced some quantities. Trees, primarily conifers, were most responsible for creating coal. Ocean growing plants seem more responsible for oil and gas formations, although some debate still exists on this subject.

Q 8. The earth's time line is shown below. Darken the portion of the time line which corresponds to the time shown on the large chart above.

A

Millions of years	5,000	4,000	3,000	2,000	1,000	500	Now
						XXXXXXX	

Use this opportunity to re-emphasize the comparatively fast development of plant and animal life on earth. Very primitive life probably did not exist until 2,000 million years ago, and land plants and animals did not exist until just 500 million years ago.

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Weather

The continents have risen, fallen, and drifted apart over the last billion years. These shifts have dramatically changed the climates throughout the world. The changing climates encouraged the appearance of new species and disappearance of old species.

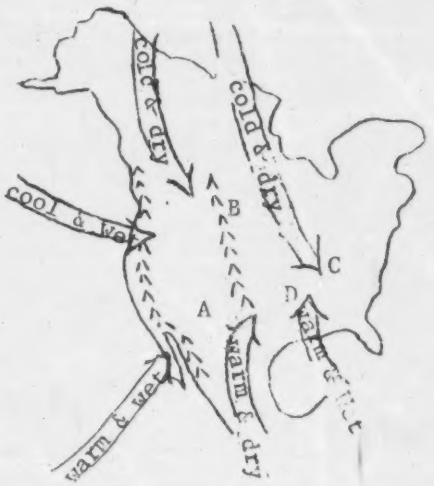
Today, we are working to control hurricanes, tornadoes, and rainfall. We may also be changing the temperature of the entire planet as more and more carbon dioxide pours into our air while jets scatter ice crystals high into the atmosphere. Only our ancestors will know if man's present activities are causing serious changes in the world's environment, for the change will be too slow to seriously bother our generations.

The film, Origins of Weather, explains how weather is created in the earth's atmosphere. The concepts shown have governed weather since the world's oceans appeared. Contients have split, world temperatures have risen and fallen, glaciers have advanced and retreated, and warm fronts have always met cold fronts just as they do today.

Five general rules govern the climate of the North American Continent as it is formed today:

1) Cold air masses are dry, and tend to move south eastward. Warm air masses tend to move north eastward.
2) Warm air masses move further north in the summer, cold fronts reach further south in the winter.
3) Warm, moist air forced high into the atmosphere cools, forms clouds, and usually rains, or snows.
4) Warm air rises and cools when meeting mountain ranges or cold air masses.
5) Air masses usually move along the routes shown on the map below.

Student Self Test



1. The map of North America has the major sources of warm and moist air indicated. Four states are marked. Explain why A is warm and dry; B is cool and dry; C is warm and moist; and D has weather which changes quickly.

2. List at least five things that help cause the weather patterns in Kansas.

3. How might man change the climate of the entire world?

4. Which parts of mountains receive the most moisture? Why?

5. During much of the last 600 million years, an arm of the ocean has covered Oklahoma, Colorado, and Wyoming. How would this water affect the weather in Nebraska and Iowa?

6. How will Kansas weather be changed if land under the Gulf of Mexico rises above sea level?

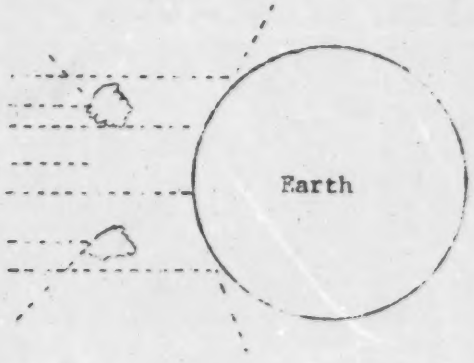
Behavioral Objective Number	Topics and Concepts
7	Students shall indicate that climates and land forms undergo continuous, but slow modification.
14	Students shall indicate that warm air from the equator warms the polar regions of the earth.
15	Students shall be able to select at least two of man's activities which may affect the climate of our planet.
16	Students shall indicate that the middle latitudes of both hemispheres have the most rapidly changing weather patterns.
17	Students shall indicate that as warm moist air is cooled and thrust upward, cloud formation will occur.
22	Students shall indicate that temperature, rainfall, history, and human actions are the factors which most influence the animal and plant life of today's world.
38	Students shall be able to select the source of most moisture received in Kansas.

Teacher Suggestions

This film is a fairly simple film, but your teaching can help present some crucial concepts for understanding the life zones and weather conditions we now find on earth.

Allow the film to run until reaching an animation sequence showing clouds reflecting light from the sun during the day.

Stop the film when the picture below appears. Place the film on "still" so that the picture remains on the screen.



Discuss the review questions below.

1. What things are most important for causing weather on our planet?

Answer: 1) The sun gives energy 2) the atmosphere controls energy distribution; and 3) the water and land absorb energy during the day and then release much of it during the night.

2. Can you think of ways that man is changing his atmosphere so that it may no longer work as shown in this film?

Answer: a) Our burning of fossil fuels has increased greatly the carbon dioxide content in our air. This may affect the planet in either of two ways:

1) It may help trap more heat in the atmosphere. (An increase of only 2 - 3° Fahrenheit in the world's average temperature would be enough to melt the Antarctica and the Arctic ice caps.)

2) The increasing temperature may put much more water vapor into the air, causing more cloud cover throughout the world. This may act to cool the planet by reflecting more heat from the earth. How much it would cool the earth before cloud cover in the upper atmosphere would disappear is uncertain. Some scientists believe that the world may warm temporarily, then cool and begin a new ice age. In any case, we <u>are</u> changing the carbon dioxide content of the atmosphere, and our ancestors over the next few thousand years will tell us if we changed the temperature of the earth.

b) Supersonic planes (such as the S.S.T.) and rockets which fly in the upper layers of our atmosphere do cause two changes.

1) They burn up ozone, which is a special form of oxygen. Whether oxygen from lower layers will move up and quickly turn into ozone, we do not know.

2_ Their exhaust releases water that turns into ice crystals.

Three possible results may occur from atmospheric changes caused by high altitude flights. If ozone decreases, as many scientists predict, this will allow more ultraviolet rays to reach the earth from the sun. Ultraviolet rays increase the mutations of cells, and would increase the rate of adaptation for small organisms, while causing increasing skin cancer in humans. If the ozone decreases, more heat energy from the ultraviolet rays would reach earth and cause warmer temperatures.

The increasing ice crystals will reflect more of the sun's energy and cool the earth.

Again, we cannot be sure of just what effect our burning more and more fuel in the upper atmosphere will have on our planet. Whether increasing ice crystals or decreasing ozone has the most effect, only our ancestors will be able to say.

c) If we should become successful in controlling hurricanes, we may change the distribution of heat and moisture throughout the planet. The large tropical storms serve as extremely important vehicles for moving heated air from the tropics to the higher latitudes. (Kansas usually receives rain within a few days of each tropical storm which moves into the Gulf States.) If these storms are effectively dissipated away from our coasts, it may cause sever shifts in rainfall and temperature patterns throughout the world.

Reverse the film momentarily so that students will be able to return to the thrust of the film when it was interrupted.

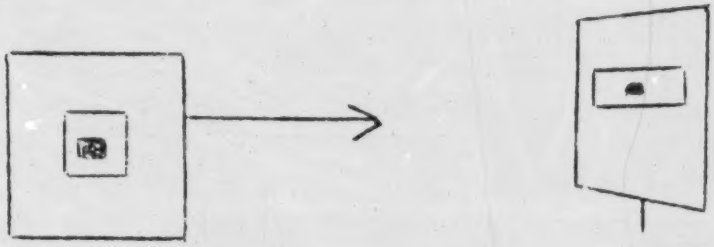
Let the film run as it explains how the warm equator air moves toward the poles; how the warm and cold fronts meet in boundaries; and how the seasons cause shifts in the boundaries.

Stop the film after seasons are explained and when the map of North America is superimposed over the rotating front lines. With the film on "still" use the picture to review these concepts with the students.

1. Why doesn't the sun warm all parts of the earth equally?

Answer:

Let students explain in their own words how the sun's rays are most concentrated at the equator, then use this demonstration: Draw a small two-inch square on a blank sheet of paper. Hold the paper about eight inches in front of the projector lens with the square facing away from the projector and toward the class. This should create a square of light that can be seen through the paper by the class. Center the drawn square in the lighted area. Now turn the paper to the left or right about 45°. This will cause the lighted square to become a rectangle with its volume about doubled.



Ask the class which position allows the paper to receive the most light. (Both papers receive the same amount of light--all that the bulb can make.)

Ask the class which positions allow the drawn square to receive the most intense light (the first position provides the most intense light, since the light is concentrated on a smaller area).

Ask the class which portion of our globe faces the sun like the first paper position and which is like the second. (The first position represents the equator, the second represents an area midway toward the poles.)

With the film on still, use the picture to review these concepts with the students.

2. If the polar regions lose more heat than the sun provides during the year, why don't the polar regions get colder and colder every year?

Answer:

Warm air from the equator flows north to warm the poles. The diagram on the film indicates that warm fronts reach only partially toward the poles, but in reality, some warmer air from areas to the south reach the North Pole at all times of the year.

3. Which part of the world would have the most variable weather during most of the year?

Answer:

The middle latitudes, such as the area covered by Kansas, will be receiving variable weather at all times. Further to the south in our continent, the weather will be variable mostly during the winter. Further to the north, the weather will be most variable during the summer, as front boundaries shift with the seasons.

4. On the average, which way do the fronts move over United States?

Answer: Toward the east. (Note: The reasons for the eastward movement over United States is complicated, and involves factors ranging from the wind deflection caused by the Coriolis Effect to the clockwise rotation of winds in a high. If students are interested in pursuing this topic, the Golden Guide book Weather" is available for classroom use from the Environmental Education office.

Reverse the film momentarily, then continue the film for about a minute.

When the animated sequence shows a cumulo-nimbus cloud producing lightning and rain, stop the film.

Ask these review questions.

1. What caused the formation of the rain clouds?

Answer: Warm moist air being thrust upward. The air cools as it rises. Cool air cannon retain as much moisture, so clouds condense and precipitation may fall.

2. How might mountains act like cold fronts to warm moist air?

Answer: The warm air rises and cools as it goes over a mountain. This causes the air to lose much of its moisture to the upper portions of the mountain.

3. Would the east or west side of a mountain receive the most moisture?

Answer: The west side. The fronts move toward the east and would cool and lose most of their moisture on the west side of the mountain.

4. How much moisture does Kansas receive from the Pacific Ocean? Why?

Answer: Very little moisture in Kansas comes directly from the Pacific. Most of the moist Pacific air is cooled in the mountains of California and other costal states. The air is dry as it moves on toward the east.

Finish running the film, and assign the student self-test questions.

Answers - Student Self-Test Questions

Q 1. The map of North America has the major sources of warm and moist air indicated. Four states are marked. Explain why A is warm and dry; B is cool and dry; C is warm and moist; and D has weather which changes quickly.

A The costal mountain ranges remove most available water from the moist air from the Pacific Ocean. State "A" receives primarily dried cool air from over the mountains and dry warm air from over Mexico.

State "B" is cool because of its Northern latitude. It is fairly dry because the warm fronts from the south seldom reach that far north, and moist air from the west seldom makes it past two mountain ranges.

State "C" is fairly warm and moist because it receives frequent doses of warm, moist air from the south. The cold fronts from the north release the moisture.

State "D" (and "C", for that matter) have quite changeable weather because they are at a latitude which experiences frequent visits from both cold and warm fronts at all times of the year. The collisions of these fronts bring on rapid weather changes.

Q 2. List at least five things that help cause the weather patterns that Kansas experiences.

A 1) The Sun, 2) The Atmosphere, 3) The Oceans and Land Masses, 4) The fact that the equator faces the sun directly much of the year and the poles do not receive as much concentrated heat, leads to big temperature differences to the north and south of us. 5) Warm, moist air moves north over us and cold air moves south; this releases moisture when the fronts collide. 6) Most fronts move east, so Eastern Kansas gets more moisture from the Gulf than does Western Kansas. 7) Mountains to the west block moist Pacific air from reaching us.

Q 3. How might man change the climate of the entire world?

A By increasing the carbon dioxide content of the atmosphere, by removing ozone from the upper atmosphere, by adding ice crystals to the upper atmosphere, and by controlling hurricanes and typhons.

Q 4. Which part of mountains receive the most moisture? Why?

A The upper part on the west side. The higher the elevation, the cooler the air. The cooler the air, the more moisture is released. The air tends to move east, so the west side of the mountain will catch most of the moisture.

Q 5. During much of the last 600 million years, an arm of the ocean covered Oklahoma, Colorado, and Wyoming. How would this affect the weather in Nebraska and Iowa?

A These states would receive much more moisture, since the easterly winds would carry moist air over them from the ocean.

Q 6. How will Kansas weather be changed if land under the Gulf of Mexico rises above sea level?

A We would become much drier, since moist air would seldom reach us from the west, south, north, or east.

A Kansas Food Web

This historical background of our continent and its weather patterns strongly influence our present life. However, to really understand our environment, you must also know what is eaten and what does the eating. In other words, you must know the members of the natural food web.

Roles in Nature

There are three basic roles organisms play in their environment:

Producers - All plants that can absorb the sun's energy and store it in their bodies are producers. Their bodies provide food for consumers and decomposers.

Consumers - All animals and plants which must eat other organisms in order to live are called consumers. Organisms which eat producers are first-order consumers. Organisms which eat first-order consumers are called second-order consumers, and so on. The bodies of consumers provide food for higher-order consumers. Their wastes provide food for decomposers.

Decomposers - are organisms that digest the dead bodies and wastes of animals and plants. The wastes of decomposers contain no energy useful to other animals. This action of decomposers releases the minerals needed by producers.

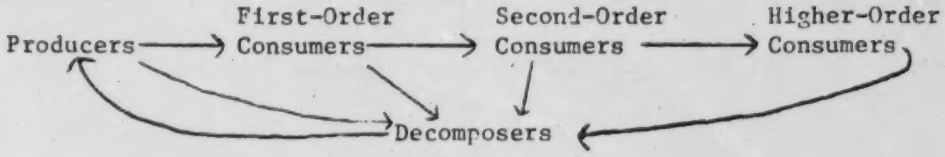


Figure 1: Summary of organisms' roles in their environment.

Sometimes, organisms can be fitted into simple food chains in their natural environment. For instance, snakes eat mice and mice eat grass roots and seeds. This makes a simple food chain:

Grass ⟶ Mouse ⟶ Snake

Usually, nature is not that simple. Mice eat several kinds of plants; plants are eaten by more than just mice; mice are eaten by more than just snakes; and snakes eat more than just mice. In other words, many, many food chains exist in a natural community. These many overlapping and interconnected food chains make up a food web.

Building a Kansas Food Web

Your teacher will assign you one or two organisms from the list below.

1)	coyote	11)	chickadee	21)	bluebottle fly
2)	mouse	12)	tapeworm	22)	walnut tree
3)	fungus	13)	grasshopper	23)	vulture
4)	grass	14)	woodrat	24)	beaver
5)	flea	15)	bull snake	25)	red fox
6)	raccoon	16)	oak tree	26)	cottontail rabbit
7)	buck brush	17)	bacteria	27)	chipmunk
8)	squirrel	18)	sow bug	28)	beetle
9)	earthworm	19)	ring-necked snake	29)	spider
10)	red-tailed hawk	20)	skunk	30)	louse

Answer these four questions about your organism.

1) What does it eat?

2) What eats it?

3) What are three food chains it could appear in?

4) What roles does it play in the environment?

Biology books, encyclopedias, dictionaries, and outdoorsmen should be able to help you answer these questions.

If your organism was a opossum, for instance, your answers should look like this:

1) What does it eat?

Mice, puffballs (a fungus), fleas, buck brush berries, young squirrels, earthworms, chickadee eggs and young, grasshoppers, young bull snakes, sow bugs, young cottontail rabbits, beetles, spiders, and lice.

2) What eats it?

Coyotes, fungus infections, fungus decomposers, fleas, tapeworms, bacterial infections and bacteria decomposers, sow bugs (when the opossum dies), bluebottle fly maggots (when the opossum dies), vultures (when the opossum dies), red foxes, beetles (when the opossum dies), and lice.

3) What are three food chains it could appear in?

a) Buck Brush ⟶ Opossum ⟶ Bluebottle Fly Maggots
b) Oak Trees ⟶ Squirrels ⟶ Opossum ⟶ Fungus
c) Grass Seeds ⟶ Mouse ⟶ Bull Snake ⟶ Opossum ⟶ Coyote ⟶ Tapeworm

4) What roles does it play in the environment?

The opossum is always a consumer. In the food chains above, it is a first-order consumer in "a," a second-order consumer in "b," and a third-order consumer in "c." After each of you have researched your organisms, your class will build a food web for a Kansas community with the information you and your classmates can provide.

Behavioral Objective Numbers	Topics and Concepts
18	Students shall be able to correctly label two common animals and/or plants with the terms decomposer, consumer, or producer.
19	Students shall be able to apply a correct set of labels to a food chain containing producers, consumers, and decomposers.
20	Given a food chain, students shall be able to select a population that would increase as a result of another organism's population decreasing within the food chain.
21	Given a food chain, students shall be able to apply the concept "Producers supply more food than their consumers" to select the population in the chain best able to feed large numbers of animals.
44	Students shall be able to apply the concept "animal species with high mortality rates tend to produce many young which require little care" to a specific problem.

Teacher Suggestions

Use the discussion in the student paper as a brief review of food chains and food webs. Two approaches may then be used with the student assignment for this paper.

Option A

Assign, or have each student select, an organism from the list in their paper. If you have 20 students, assign the first 20 organisms. The list is set up to include decomposers, producers, and different levels of consumers. Have the students answer the four questions for their organism as best they can, and collect this assignment as homework.

If you have more than thirty students, add the organisms listed below.

31) Butterflies	36) Ragweed
32) Snail	37) Virus
33) Centipedes	38) Hickory Tree
34) Deer	39) Sapsucker
35) Termites	40) Rattlesnake

Option B

Duplicate page G-4, and assign one organism on the chart to each student. If students connect lines to a dot about 0.5 cm into the circle (as done on the transparencies), the connecting lines between all organisms will be more evident.

You should point out that all names indicate <u>populations</u> of organisms, so many arrows may lead to or from the same name.

Followup Exercise

Following discussion of the food webs and chains developed by the students, use the transparencies, inserted following Paper P to show how a complete food web can be built from the partial information developed by each person in the class.

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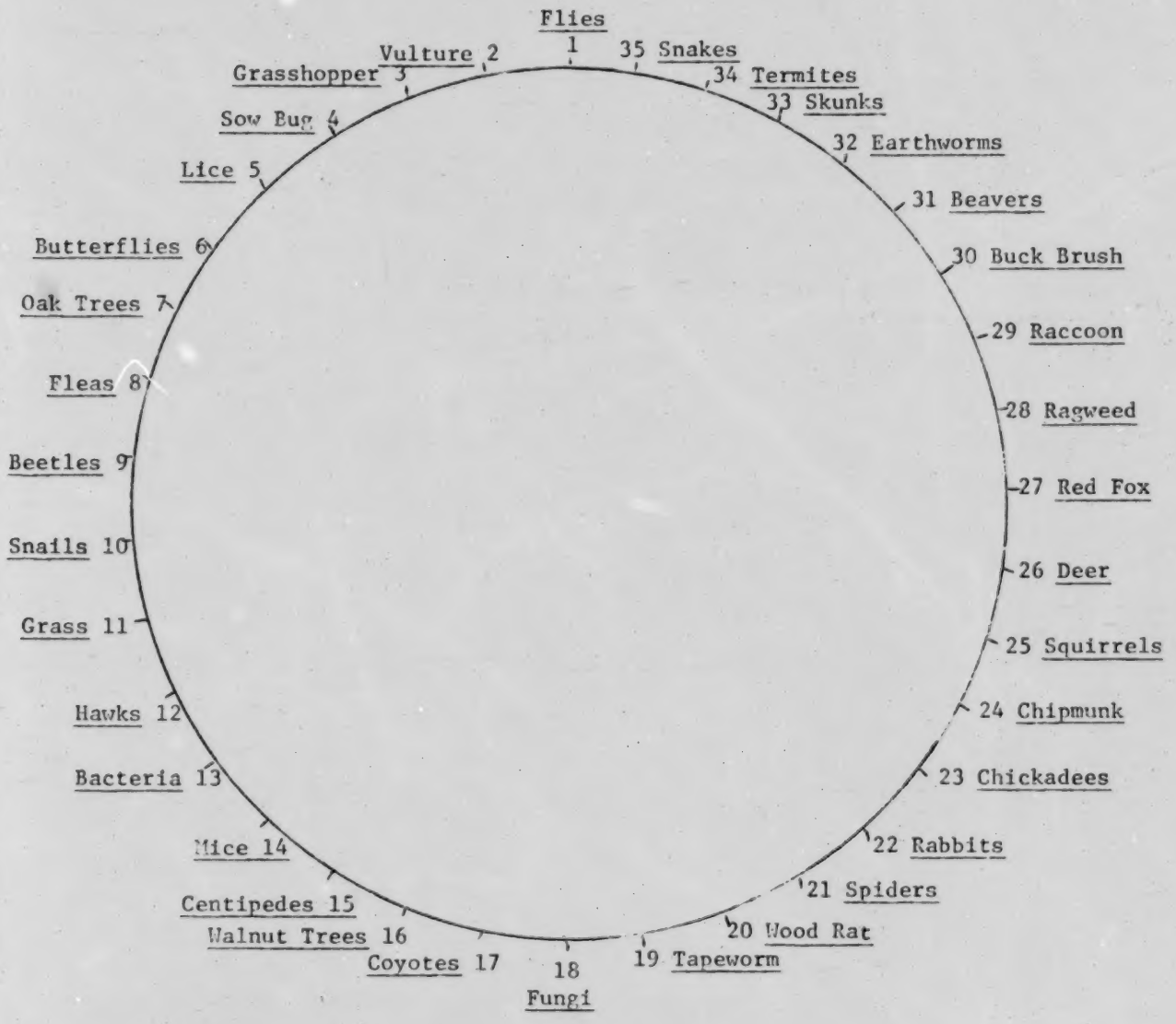
Food Web Exercise

1. Draw a line between the organism assigned to you and all organisms eating and/or being eaten by it.

2. In the middle of each line, place an arrow pointing toward the higher order consumer. (sparrow ←— seed) If the populations may use each other, indicate with two arrows. (deer ←→ fungi)



Lay the partial webs individually over the base sheet to build the composite. While doing this, use the following questions as a review.

Review Questions

1. Which of these organisms are first or second-order consumers? Producers? Decomposers? Test results indicate that many slow students cannot identify common organisms by their roles in food webs. Ask these students to identify the roles of grass, oak trees, foxes, rabbits, snakes, fungi and so on.

2. Which populations would increase and which would decrease if mice, lice, hawks, foxes, or grass would die? Most students can use these concepts easily, but the slowest 25 percent have real troubles.

3. Are there more pounds of producers, first or second-order consumers in the food web?

   Most students do not realize that the producers contain the most mass and energy in any food chain. When given a practical problem requiring selection of the population best able to feed larger numbers of consumers, first and second-order consumers are usually selected. Review these concepts using many different chains.

4. If you wanted to have a large population would you be a first, second, or third-order consumer?

Answer: A first-order consumer. Point out that countries such as China and India eat much more plant food and much less animal food than the United States. You might also point out that most diets made from plants lack the quality protein needed to develop full mental and physical capacities of the people. A quality diet can be developed for humans from only plants, but it is quite difficult and requires a wide variety of plants. Therefore, a population eating primarily plants may be large, but the individuals may not be as healthy as those able to eat more meat.

5. Which animals produce the highest number of young per parent each year?

   Work to help students realize that the higher the mortality rate (the more likely the animal will be eaten) the more young the average parent will produce.

6. How many children, will produce grandchildren for the average mouse, fly, oak tree, and vulture?

   The average number of reproducing children for most animals will be two. A higher average will result in population growth, a lower average in decline, or two will result in a stable population. Most natural populations are fairly stable. Predation, disease, adverse weather, and starvation wipe out most young, whether one million or ten are produced each generation.

   Oak trees (which may be self-fertilizing) asexual organisms average only one reproducing offspring per parent.

You, or the students, may question some of the lines on the five food webs. It should be pointed out that the lines indicate not only the common interactions, but also the possible interactions. For each of the five partial webs on the transparencies, the questionable connections are indicated by number and explained.

Partial Web - Oak trees (Transparency 1)

3) Grasshoppers will eat oak leaves.

4) Sow bugs eat decaying oak leaves.

5) Plant lice attack oak trees.

6) Oak Leaf Miners, and Tent Caterpillars are in the "butterfly" groups (they are moths).

10) Some snails may eat foliage.

13) Bacteria acts as a disease on the tree and to help decompose the tree.

20) Woodrats eat acorns and some leaves.

22) Rabbits chew twigs and bark of young trees.

29) Raccoons will eat acorns.

33) Skunks will eat soft-skinned acorns.

Partial Web - Grass (Transparency 2)

1) Flies attacking wheat (a grass) include the Hessian and Wheat Stem flies. Many other flies attack the native grasses.

5) Plant lice eat many grasses.

6) Many caterpillars eat grasses.

23) Chickadees eat a few grass seeds.

33) Skunks may eat a few grass seeds, wheat, and corn.

34) Termites eat plant materials of all types in the forest litter.

Partial Web - Red Fox (Transparency 3)

1) Fly maggots eat dead foxes and screw worms would invade wounds on a live fox.

6) Caterpillars are eaten by foxes.

8) Fleas parasitize foxes, and the foxes will occasionally catch and eat the flea.

9) Carrion beetles eat dead foxes, and foxes eat beetles.

17) Coyotes will kill foxes.

25) Young squirrels, particularly ground squirrels, are eaten.

Partial Web - Rabbits (Transparency 4)

1) Fly maggots eat dead rabbits and screw worms infect wounds. Mosquitoes also do their thing.

4) Sow bugs eat the decayed remains of rabbits.

7) Rabbits eat twigs and bark of young trees, as well as the (softer) nuts.

13) Bacteria as a disease and decomposer affects rabbits.

29) Raccoon will eat young rabbits.

32) Rabbits eat twigs and bark of young trees, as well as fruit which falls to the ground.

33) Young rabbits are eaten by skunks.

35) Young rabbits are eaten by snakes.

Partial Web - Fungi (Transparency 5)

1) Maggots eat all mushrooms, puffballs, and mold found in decaying food.

2) Vultures eat fungi in dead material.

4) Sow bugs eat mold on their normal food.

9) Beetles eat mold on their normal food.

10) Snails eat much decaying plant material and its attached fungi.

13) Bacteria are Fungi, and they are broken down and consumed by other forms of fungi.

14) Mice eat puffballs as well as fungi on seeds.

26) Deer actively search for puffballs and morels.

33) Skunks eat puffballs and fungi on their regular foods.

Biomes in the United States

Just as we divide the United States up into cities and states, ecologists divide the country into communities and biomes. Communities are made of plants and animals which live together in a natural area, such as a pond, woodland, or even a rotten log. All animals and plants in a community are members of its food web. Biomes are large areas of land with similar kinds of communities throughout. For instance, pond and forest communities are much alike in all states from Missouri to New York. This is why eastern United States is classified as one biome (the middle latitude deciduous forest biome).

What Causes Biomes?

People vacationing in the United States often are surprised at the variety of plants and animals found throughout our land. They seldom stop to ask why those plants and animals live where they do.

Moisture patterns play an important role in drawing the boundaries for biomes. Mountains collect much of the moisture blowing east from the Pacific Ocean. The dry air moving off the mountains causes deserts in Southwestern United States. Dry grasslands over much of the middle third of the United States also arise because of mountains to the west. Warm, moist air from the Gulf of Mexico carries water north and east to provide most of Eastern United States with moisture and a different biome.

Temperature also helps determine biome boundaries. An inch of moisture will help plants more in a cool climate than in a warm area. Beautiful conifer forests are found in Northern Canada where the days are never too hot. Arizona, which receives almost the same moisture, has a desert biome because its heat quickly evaporates the water.

The history of an area also helps determine the plants and animals which will live in it. For instance, hemlocks grow in the cool coniferous forest biomes of Maine, Oregon, China, and Japan. No hemlocks are found in the coniferous forests of Russia, Europe, and Canada. Moles live in Eastern and Western United States, but not in a 200 mile strip through Central United States.

The puzzle of why very similiar plants and animals grow in widely separated areas, but not in other areas with similiar climate is repeated thousands of times in biomes across the world. To solve these puzzles, ecologist have turned to fossil history to learn the origin of the scattered communities.

A study of fossil history indicates that 200 million years ago (during the Triassic Period) North America and Europe were joined together. A massive coniferous forest covered Europe, Asia, and North America. As the continents separated, mountains rose, and weather patterns throughout the world changed. Most of the ancestors of today's hemlocks died. Today we find only a few scattered populations of a family of trees which were once very, very common.

Fossils of moles date back to early in the Tertiary Period, over 50 million years ago. At that time, North America had no Rocky Mountains, and moles lived throughout America. As time passed, the Rockies began to push higher and higher until they created a barrier which no mole could cross. The moles that continued to live on either side of the mountains changed as millions of years passed. Today moles of one genus live in the Pacific coast states and moles of several different genera live from Kansas to the Atlantic Ocean. All moles belong to the same family, and trace their origins back to the primitive moles living when the Rocky Mountains were just hills.

A more recent cause of changes in biomes is man. We have nearly eliminated the middle latitude deciduous forest which used to stretch from Missouri to New York. We have turned this biome into an artificial grassland biome. Hundreds of animals such as the buffalo, elk, wolf, couger, and prairie dog have had their populations severely reduced. In fact, our activities have changed the natural populations of nearly every plant and animal in the United States. Most populations have been partially replaced by domestic animals, plants, and imported organisms such as starlings and dandelions.

Temperature, rainfall, and the history of an area determine the kinds of plants and animals that could survive and reproduce under natural conditions. Man is deciding which organisms do survive. Whether or not man is one of those animals which survives over the next million years is yet to be seen.

The map on page three shows the major natural biomes of the United States. Use this map to help answer the questions for this paper and the following papers.

Student Self-Test

1) The United States has six major natural biomes. Which two have been changed the most by man?

2) Which two biomes in the United States receive the most moisture? Why?

3) List four factors that strongly influence the kinds of animals and plants that can live in a particular area.

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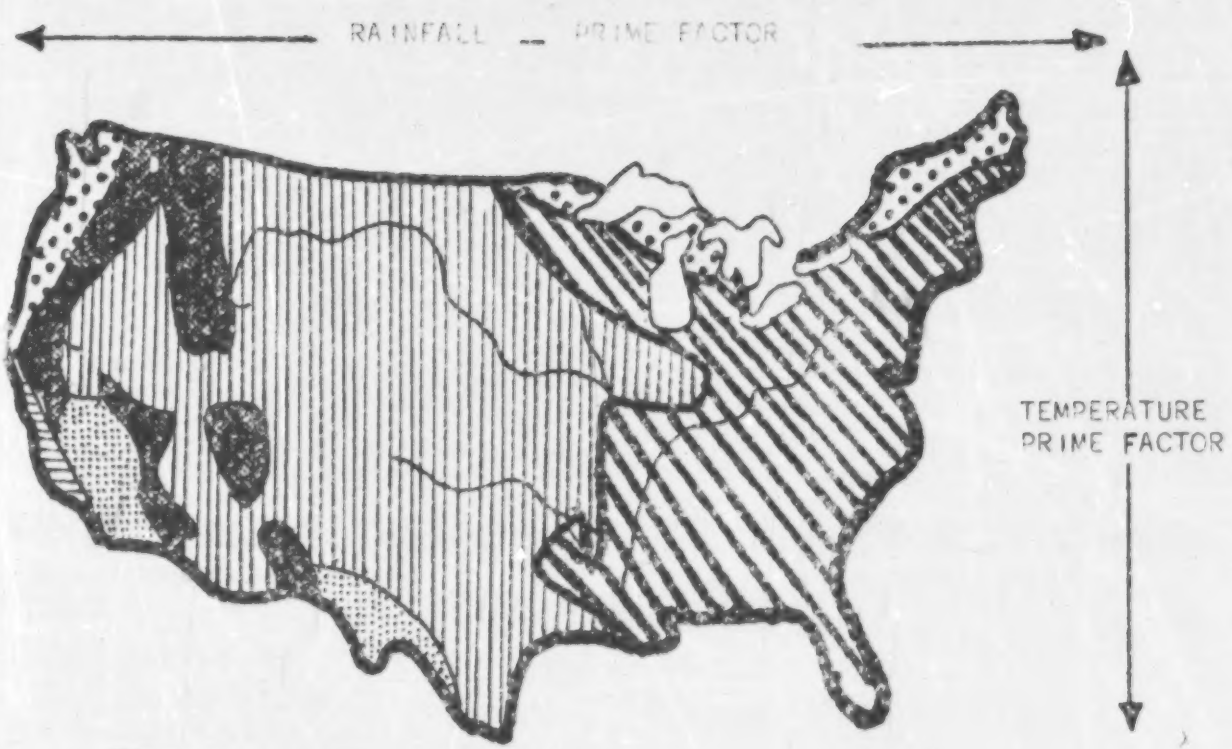
MAJOR BIOMES OF THE UNITED STATES



MIDDLE LATITUDE DECIDUOUS FOREST

MIDDLE LATITUDE GRASSLAND

DESERT

NORTHERN CONIFEROUS FOREST

CHAPARRAL

MOUNTAINS (COMPLEX ZONATION)

Behavioral Objective Number	Topics and Concepts
7	Students shall indicate that climates and land forms undergo continuous, but slow modification.
8	Given a hypothetical problem, students shall indicate that the animals and plants on both sides of a new land bridge will undergo population changes.
10	Apply the concept, "the normal fate for most species is extinction," to a specific problem.
22	Students shall be able to select temperature, rainfall, history, and humans as the factors which most influence the animal and plant life of today's world.
23	Students shall be able to select a probable food chain for the middle latitude grassland, middle latitude deciduous forest, or northern coniferous forest biomes.
37	Students shall be able to match a biome with adaptations unique to the animals of that area.
39	Students shall be able to match a biome with three adaptations unique to the plants of the area.

Teacher Suggestions

This paper should serve as a quick review of the factors which influence where animals and plants live. It should be used with Paper I, "Life Zones of the Central Rockies."

By the conclusion of the module, students should be able to select common food chains and adaptations for four biomes: middle latitude deciduous forests, middle latitude grasslands, deserts, and the northern coniferous forests. However, these biomes will be developed in more detail in Paper I and on the field trip. Their labels need not be stressed at this time.

Answers - Student Self-Test Questions

Q 1. The United States has six major natural biomes. Which two have been changed the most by man?

A Most of the middle latitude deciduous forest biome has been destroyed and turned into grasslands of wheat, corn, cotton, etc.

The middle latitude grassland has had extensive changes in the populations of native plants and animals, but it remains a "grassland" biome.

All other biomes have been modified toward grassland and city habitats, and students could legitimately defend any biome they choose, because man has made extensive modifications in all.

Q 2. Which two biomes in the United States receive the most moisture? Why?

A The middle latitude deciduous forest and the northern coniferous forest in the Western United States receive the most rainfall. Moisture blowing east from the Gulf of Mexico and the Pacific, water these areas. (The Chaparral biome in Southern California receives very little rain during the summer due to costal mountain ranges and prevailing winds in that area.)

Q 3. List four factors that strongly influence the kinds of animals and plants that can live in a particular area.

A Moisture and temperature determine the kinds of animals and plants that <u>could</u> live in an area. History determines the kinds of animals and plants that <u>will</u> be living in an area under natural conditions. Humans are playing an ever bigger role in determining <u>if</u> the animals and plants are allowed to live.

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Life Zones of the Central Rockies.

Many different communities exist on a mountain slope. Increasing elevation results in cooler temperatures, higher rainfall, and more intense sunlight. These three factors create very different climates for the plants and animals found at each elevation. In the Rocky Mountains, as one example, increasing elevation by 1,000 brings an average temperature decrease of 3°F, and an increase of about 6 inches of moisture yearly. Thus, a climb of 5,000 feet will encounter communities living in very different environments.

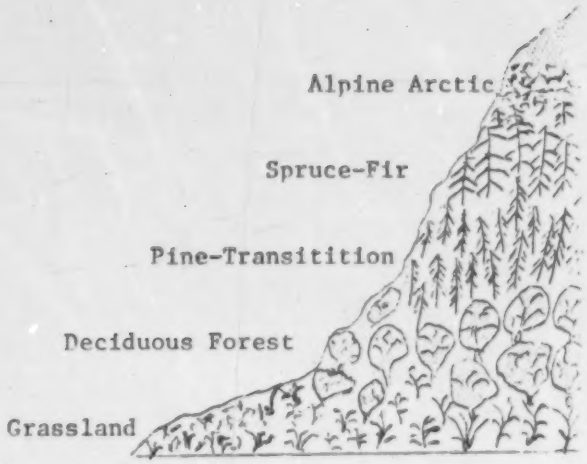


Figure 1. Life zones of the Central Rockies.

The mountain communities can be grouped into life zones which are much like the larger biomes found throughout the world. As you view the film, Life Zones of the Central Rockies match the mountain life zones with the biomes they resemble. In addition, note the animals and plants found in each zone and construct sample food chains for each zone.

Student Self-Test

1. List three factors which create the life zones found at different elevations of a mountain.

2. What biome is found on the flatland below the Rocky Mountains?

3. Write down two grassland food chains using animals and plants shown in the film.

4. Make at least two food chains for the Pine - Transition Zone. Indicate which organisms are producers, first and higher-order consumers in your chains.

5. What kinds of animals are most likely to visit several life zones during the year? Why?

6. What biome in the United States would be similar to the Pine - Transition and Spruce - Fir Life Zone?

7. What state would have a biome with weather similar to the Alpine - Arctic Mountain Zones?

8. Which life zone has the simplest food web?

Behavioral Objective Number	Topics and Concepts
17	Students shall indicate that, as warm moist air is cooled and thrust upward, cloud formation will occur.
18	Students shall be able to correctly label two common animals and/or plants with the terms decomposer, consumer, or producer.
19	Students shall be able to apply a correct set of labels to a food chain containing producers, consumers, and decomposers.
20	Given a food chain, students shall be able to select a population that would increase as a result of a decrease in another animal's population within the food chain.
23	Students shall be able to select a probable food chain for the middle latitude grassland, middle latitude deciduous forest, or northern coniferous forest biomes.

Teacher Suggestions

Before showing the film, have the students skim through the introductory paragraphs and the self-test questions. Each student should prepare to note the animals and plants shown in the different life zones.

The film will first give a general review of the four Mountain Life Zones. Stop it after it shows barren snow-covered mountain peaks and before it begins discussing the Grassland - Deciduous Forest Zone the second time.

Give the students a few minutes to answer question one, then call on several students to give their answers.

Continue showing the film until it begins to introduce the Pine Transition Zone for the second time. Stop the film once again, and give the students time to answer questions two and three. Call on several students to provide answers for their questions, and make a food web on the board as suggested under the answer for question three.

Continue the film until the discussion of the Pine - Transition Zone is finished. Stop the film and allow the students to answer questions four, five, and six. Discuss the answers before continuing.

Finish showing the film, answer, and discuss questions seven and eight.

Answers - Student Self-Test Questions

Q 1. List three factors which create the life zones found at different elevations of a mountain.

A Increasing elevation will cause more moisture to fall and increasing elevation will create colder temperatures and greater temperature extremes. Animals and plants that could live in warmer or drier conditions will be eliminated and replaced by organisms adapted to colder, wetter conditions as elevations increase. Increasing wind speed and increasing light intensity also influence the types of organisms able to live at various elevations.

Student Self-Test

1. List three factors which create the life zones found at different elevations of a mountain.

   a. b. c.

2. What biome is found on the flatland below the Rocky Mountain?

3. Write down two grassland food chains using animals and plants shown in the film.

   a.

   b.

4. Make at least two food chains for the Pine - Transition Zone. Indicate which organisms are producers, first and higher-order consumers in your chains.

   a.

   b.

5. What kinds of animals are most likely to visit several life zones during the year? Why?

6. What biome in the United States would be similar to the Pine - Transition and Spruce - Fir Life Zones?

7. What state would have a biome with weather similar to the Alpine - Arctic Mountain Zones?

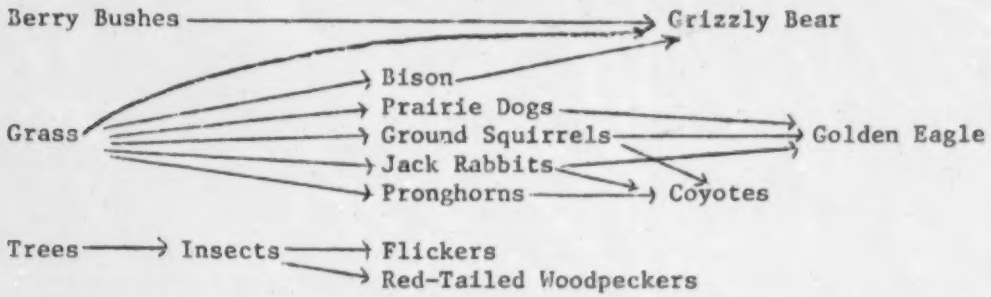
8. Which life zone has the simplest food web? Why?

Q 2. What biome is found on the flatland below the Rocky Mountains?

A Middle Latitude Grassland

Q 3. Write down two grassland food chains made of animals and plants shown in the film.

A Use student food chains and suggestions to construct on the chalkboard a food web, such as the one shown below.



Q 4. Make at least two food chains for the Pine - Transition Zone. Indicate which organisms are producers, first and higher-order consumers in your chains.

A Work to get simple and complicated food chains for this region, and have students label each chain until most students can do one easily. Some sample chains from the film are given below.

Producers	First-Order Consumer	Second-Order Consumer	Third-Order Consumer
Water Plants	Moose		
	Canada Geese	Coyotes	
Berry Plants	Bohemian Wax Wings		
	Black Bears	Fleas	
	Mule Deer	Mountain Lion	Vultures
Flowering Plants	Bees (Honey)	Black Bear	
	Insects	Water Oozle	
Grass	Elk	Mountain Lion	Tapeworms

Before moving to the next question, ask the students what would happen to the first-order consumer populations if the producers all died. Ask what would happen to the first-order populations if the second-order consumers all died.

Q 5. What kinds of animals are most likely to visit several life zones during the year? Why?

A 1) Large first-order consumers looking for food, protection from winter weather and from summer heat.

2) Large second-order consumers looking for the migrating first-order consumers.

Q 6. What biome in the United States would be similar to the Pine - Transition and Spruce - Fir Life Zones?

A The middle latitude coniferous forest.

Q 7. What state would have a biome with weather similar to the Alpine - Arctic Mountain Zone?

A The Tundra biome of Alaska would be similar, although there are quite different animals, light patterns, and ground conditions in the two areas.

Q 8. Which life zone had the simplest food web?

A The Alpine - Arctic Zone. Point out that this means that animals in this zone will undergo tremendous changes in populations from year to year, as first and second order consumers get in and out of balance.

Why Do Communities Change?

Communities can change rapidly. Floods may kill trees and bury grass under mud. Fire may destroy forests, and erosion may destroy surface and soil communities. Humans destroy natural communities as roads are built, soil is plowed, and trees are cut.

Communities may also change slowly. Ponds fill with silt, and marsh communities replace pond communities. Lichens and moss break-down rock to form soil. New soil allows the growth of grass which replaces the moss and lichens. Forests of elms are replaced by oaks. The slow changing of communities is called ecological succession.

Ecological succession may occur in two or three years, as when sunflowers and ragweeds growing on disturbed soil are replaced by grasses. Succession may occur over thousands of years as large lakes fill, marshes develop and are replaced by forests. In each case, the species which are successful create an environment which allows competitors to become more successful and to replace the original community. For instance, marsh plants create so much material that the marsh fills and is destroyed. The eventual result of all ecological succession is a climax community which will remain stable under natural conditions for tens of thousands of years.

The climax community of western Kansas is a short grass prairie. The grasses of the prairie are able to reproduce and keep competitors from invading. In a similiar way the climax community of north-eastern Kansas is an Oak-Hickory forest which is able to thrive and reproduce for thousand of years without major change.

Sand Dune to Forest: Ecological Succession is a film about a type succession not found in Kansas, However, the forces that cause succession are the same wherever they are found.

Student Self-Test

1. List three ways that animals and plants can change the quality of soil.

2. What are the most important changes that cause communities to move from one stage of succession to the next?

3. Do food webs become more or less complicated as succession advances toward the climax stage.

4. What biome was shown in this film? List two food chains for the biome.

5. Do you agree or disagree with this statement? "Successful animals and plants always change their environment, and the changing environment leads to replacement of the original organisms by new animals and plants." Give examples to support your answer.

Behavioral Objective Number	Topics and Concepts
24	Students shall be able to select the environmental changes most responsible for encouraging succession in a forest.
25	Students shall indicate that succession moves from simple to complex food webs.
26	Students shall be able to apply the concept "successful animals and plants usually alter their environment until they are no longer successful," to a specific problem.

Teacher Suggestions

Have the students read the paper and the student self-test questions. Show the film without stopping for discussion, unless student interest begins to lag during the film. Our objectives for this film depend on understanding succession as a whole, and do not require students to really understand each stage.

The introduction to the film is poor, and badly spliced. You may wish to run this portion through the projector before class begins.

Answers - Student Self-Test Questions

Q 1. List three ways that animals and plants can change the quality of soil.

A
1) Animal and plant bodies decay and create humus for soil.
2) Plants hold soil and keep it from eroding
3) Plants shade soil and protect it from wind--this increases soil moisture.
4) Animals burrow in the soil and allow more air and organic matter to reach deeper layers.
5) Decomposers decay plants and animals and release nutrients for plants.

Q 2. What are the most important changes that cause communities to move from one stage of succession to the next?

A The <u>changing soils</u> and <u>increasing shade</u> allow different plants to survive and reproduce. Different plants bring different animals. Students frequently indicate that the climate changes as forests mature. Emphasize that the climate remains the same <u>but</u> the changing soil, shade, and wind protection increase the available moisture.

Q 3. Do food webs become more or less complicated as succession advances toward the climax stages?

A Food webs become more and more complex as the stages of succession move along. A good illustration of this is a vacant lot. It may have started as a good lawn, but after a few years, it will contain many kinds of plants and animals.

Q 4. What biome was shown in this film? List two food chains for the biome.

A The Middle Latitude Deciduous Forest biome. Try to have your students create and label some five-member food chains with a decomposer as the last step. Sample chains are given on page J-4.

Student Self-Test

1. List three ways that animals and plants can change the quality of soil.

   a.

   b.

   c.

2. What are the most important changes that cause communities to move from one stage of succession to the next?

3. Do food webs become more or less complicated as succession advances toward the climax stage. Why?

4. What biome was shown in this film? List two food chains for the biome.

   a.

   b.

5. Do you agree or disagree with this statement? "Successful animals and plants always change their environment, and the changing environment leads to replacement of the original organisms by new animals and plants." Give examples to support your answer.

Producer	First Consumer	Second Consumer	Third Consumer	Decomposer
Grass	Grasshopper	Skink	Snake	Fungus
Oak Tree	Caterpillar	Warbler	Raccoon	Flesh Fly Maggots

Q 5. Do you agree with this statement? "Successful animals and plants always change their environment, and the changing environment leads to replacement of the original organisms by new animals and plants." Give examples to support your answer.

A In general, this statement is true. It certainly holds true for the early succession stages that modify the environment so later stages can move in. An example from the film is the cottonwood tree, which is very successful in growing on the sand before other trees can take root. However, the cottonwood stabilizes the sand, provides shade and better soil. Soon these conditions allow new species of plants to replace the cottonwood.

The climax stage provides a partial rebuttal answer. It will be stable for very long periods of time. Its very complex food webs will take a lot of strain without breaking and most species will survive. However, eventually even the climax communities will be replaced by new and stronger species of animals and plants.

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What Causes Population Changes?

Three general observations explain the population changes experienced by successful organisms.

1) All species have good, and bad years, so that a natural graph of any population has "ripples" caused by years of disease, good weather, floods, and so on.

Figure 1. Natural population graphs.

2) All species will grow very quickly until famine, disease, predation, or psychological pressures of competition for homes, mates, and "elbowroom" control the growth. If the population grows so large that it severely disturbes its environment, then the entire species may die.

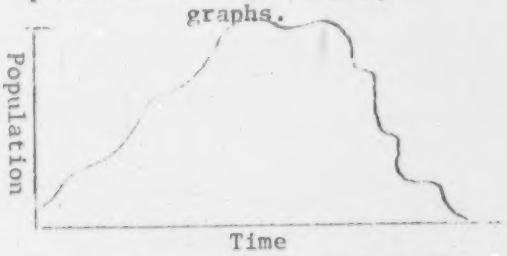

Figure 2. Excess growth graph.

3) If the rapidly growing population is brought under control before the environment is badly disturbed, then the species can come into balance with its environment. This is the normal curve for successful species in a new environment, and for species with new adaptations.

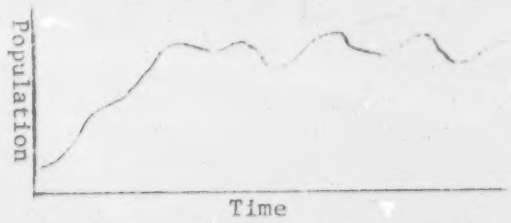

Figure 3. Growth, then natural balance.

The film Population Ecology shows the population growth rates of different species under artificial and natural conditions. Use the film, your knowledge, and the explanations above to answer the questions below:

Student Self-Test

1. Smallpox used to kill millions of people. It is now controlled by vaccinations. Flue viruses affect many more people, but do not often kill. Draw a possible population graph for each of these diseases.

2. In the experiments with fruit flies, bacteria, and mice what environmental conditions allowed their populations to increase rapidly? Give at least three conditions.

3. Can you provide two examples of animals that have had population explosions in the last two centuries?

4. What controls the populations of animals in the natural world?

5. What has allowed the human population to explode?

6. What should the curve of human population look like for the next 100 years? Why?

7. What may be causing the population growth in the United States to slow?

Behaviroal Objective Number	Topics and Concepts
20	Given a food chain, students shall be able to select a population that would increase as a result of a decrease in another animal's population within the food chain.
21	Given a food chain, students shall be able to apply the concept "Producers supply more food than their consumers," to select the population in the chain best able to feed large numbers of animals.
24	Students shall be able to select the environmental changes most responsible for encouraging succession in a forest.
26	Students shall be able to apply the concept "Successful animals and plants usually alter their environment until they are no longer successful," to a specific problem.
27	Given a verbal description of a change which would remove a population from a state of equilibrium, students shall be able to select an appropriate graph showing the population before and after the change.
40	Students shall be able to select the factors which most limit the populations of large carnivores.

Teacher Suggestions

Run the film until the experiment with mice is finished. This occurs after the size of their environment has been increased. Stop the film at this point.

Point out to the students that the populations of mice in these experiments will probably die, just as in the cases of the fruit flies and bacteria. A very similar experiment was recently completed with rats. They were given unlimited food and water, were kept disease-free and the cages were cleaned. Their space was controlled, just as in the mouse experiment in the film. The rat experiment had a large amount of space, and at the peak growth, there were over 2,000 rats. After five years, the last rats died. When the population was at its peak, poor mothering and abnormal childhoods led to the sterility of the final generation of rats.

Have the students answer and discuss questions one, two, three, and four.

Continue the film about two minutes. When a picture of aborigines appears, stop the film. Review student answers to question number four above, and see if the film has mentioned any additional factors that influence the population of a species.

Continue showing the film until its conclusion is reached. The portions of the film giving population figures for growth in the United States today are now outdated. We have slowed down, at least temporarily, to a level that will reach zero growth in the early 21st century. The picture is not so rosy for the developing countries. Their populations are still growing very fast, and the pictured alternatives for the world's growth are still possible.

Answers - Student Self-Test Questions

Q 1. Small pox used to kill millions of people. It is now controlled by vaccinations. Flu viruses affect many more people, but do not kill. Draw a possible population graph for each of the diseases.

A It might be useful to put two large graphs on the board, and run both from 1700 to present. Have students decide whether they will graph the disease viruses for United States, or for the world. If United States is chosen the frequency of small pox would rise until the mid 1900's, when vaccination was begun and would reach very low levels in the 1900's. Flu would rise rapidly, as does the human population. If the world population was chosen, small pox would start high and the frequency would continue to rise until the early 1900's. Flu would rise rapidly throughout the graph.

Use this exercise to make two points: 1) contagious disease rates for disease which cannot be prevented rise faster than the human population growth, since crowding encourages disease spread; and 2) the ability to control disease is a "behavioral adaptation" by man which has allowed his population to grow very rapidly.

Q 2. In the experiments with fruit flies, bacteria, and mice, what environmental conditions allowed their populations to increase rapidly? Give at least three conditions.

A The populations had plenty of food, plenty of space, no competitors, no predators, and no disease when the experiments began.

Q 3. Can you provide two examples of animals that have had population explosions in the last two centuries?

A Rabbits had a population explosion in Australia. Only a rabbit disease introduced from England was able to bring the explosion under control. Starlings and English Sparrows both showed population explosions after being introduced into America. Despite man's efforts, both birds are still growing ever-larger populations. The Gypsy Moth is in the midst of a population explosion in America today. It is not under control by any means. Man and all of his domestic plants and animals are still in the midst of a world-wide population explosion. This will be discussed later in the film.

Q 4. What controls the populations of animals in the natural world?

A When first stopping the film, solicit student suggestions for this question. List their suggestions on the board. Show the second portion of the film then discuss the factors which do determine population size:

1) The supply of food.
2) The presence or absence of predators, parasites, and disease.
3) The degree of crowding.
4) Changing local conditions of air, water, or soil quality.
5) Changing weather conditions, such as drought or flood.
6) Competition between species.

Use these follow up questions:

A) Why is the statement "successful plants and animals alter their environment until they are no longer successful" usually correct?

Students should realize that most of the tools used by nature to control populations work most effectively on large populations. Disease, starvation, predation, competition for nesting spaces and food during droughts, etc. all hit large populations more than small.

B) Which of these factors encourage succession in a forest?

Students should realize that crowding, changing soil and water quality, and competition for sunlight all work to change the species conposition of the entire community.

Q 5. What has allowed the human population to explode?

A The most important contributors are:

1) The use of fossil energy has greatly expanded man's power to change the world. Each American has the equivalent of over 200 slaves working for him, when we consider the amount of energy the United States uses, the number of people in the country, and the amount of work a human can do. (As one example of dependence on fossil energy - It takes more fossil energy to transport, make, cook, and wrap a McDonald's hamburger than man can get from digesting the hamburger.)

2) Medical advances allow us to control parasites and diseases.

3) Increasing knowledge allows new products, better crops, and new ways to change and control our environment.

Q 6. What should the curve of human population look like for the next 100 years? Why?

A If all men in the world are ever to live as comfortably as we Americans do, the world-wide population must level off. Even then, there probably is not enough food, fuel, minerals, wood, and space for the whole world to live at the level we in the United States enjoy today. The larger the population grows, the poorer will be the quality of life for most people.

Q 7. What may be causing the population growth in the United States to slow?

A Let the students offer their suggestions and accept their comments as the answer.

Survival - What Does It Take?

Mother Nature is seldom nice, gentle, or compassionate; but she is always patient. The film, "World in a Marsh," shows nature at work in a marshland community filled with thousands of animals trying to survive. Before you watch it, you should review three concepts.

Adaptations are special characteristics that enable organisms to survive in their environment. Any difference between species can be considered an adaptation. The question which biologists try to answer is how each adaptation helps the animal survive.

Turn to page L-2. Each of the bird beaks are adaptations for eating different kinds of food. Each of the feet aid survival in different types of life styles. Try to figure out how each adaptation would help the bird that possesses it.

Ecological Niches refer to the way an animal or plant lives. An organism's niche includes where it lives, all of the animals and plants that it eats, all of the animals (and plants in a few cases) that eat it, and all organisms that live in its community. It also includes the organism's response to non-living parts of the environment, such as sunlight and storms.

The niche of humans is very, very big. Your niche includes cows from Kansas, peanuts from Africa, lettuce from California, and coffee from South America. The dogs, cats, goldfish, and spiders that may share your home are in your niche. Your niche even includes the mosquitoes and chiggers that consume you in the woods and the trees that were cut to make the desk and chair that you use.

No other animal has such a large niche as man, for our most important adaptation - intelligence - allows us to live in biomes from the North Pole to the tropics.

Competition is a third concept that this film illustrates. Competition occurs when two organisms occupy similar niches. For instance, Kansas grasses and wheat have similar consumers, similar weather requirements, and similar soil requirements. They both have about the same niche. Under natural conditions, a wheat field would become a grass field within four years. Grasses would cause the extinction of wheat. Only by plowing, cutting, and replanting can man enable wheat to occupy the same niche as grass.

Competition does not usually involve fighting. Instead, it involves organisms trying to survive and reproduce a new generation. In the case of wheat vs. grass, wheat seeds are so attractive that nearly all of the seeds for the new generation will be eaten under natural conditions. Native grass seeds are not so attractive, so some seeds will survive to produce new generations.

Competition between trees may include shading and how much water can be removed from the ground. Competition between bull snakes and blue racers may involve which one can capture the most mice, escape the most consumers, and find the best winter den.

Competition can also occur within a species. Male elk compete for the rights to control female elk, and birds complete for the right to control nesting grounds and feeding areas.

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BIRD ADAPTATION PICTURES

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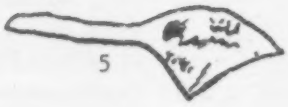
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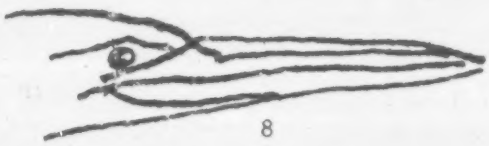
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All kinds of competition usually improve a species' ability to survive. Organisms with new and better combinations of adaptations will survive more often and will reproduce more young. In this way, each generation is a little better suited for its environment than the one before.

STUDENT SELF-TEST

1. List four adaptations necessary for a rat to survive and compete with other animals.

2. List at least eight adaptations which allow marsh animals and plants to survive.

3. Describe the marsh niches of dragon flies and bull frogs.

4. Why must grebes and bull frogs lay such different numbers of eggs in order to survive? Give at least three reasons for the differences.

Behavioral Objective Number	Topics and Concepts
10	Students shall be able to apply the concept "the normal fate of most species is extinction" to a specific problem.
18	Students shall be able to correctly lable two common animals and/or plants with the terms decomposer, consumer, or producer.
19	Students shall be able to apply a correct set of lables to a food chain containing producers, consumers, and decomposers.
26	Students shall be able to apply the concept, "successful animals and plants usually alter their environment until they are no longer successful" to a specific problem.
28	Students shall be able to apply the concept "all differences between species represent adaptations for survival in the niches occupied by the species," to a specific animal.
29	Students shall be able to apply the definition of "niche" to select the information required to best define an animal's niche.
30	Students shall be able to use the law "Survival of the Fittest" to select the most essential characteristic of a mutation with adaptive value.
31	Students shall be able to apply the concept "Organisms are fit only when many generations of their offspring can reproduce successfully" in evaluating the successful human society.

Teacher Suggestions

Have the students read the written portion of this paper, then discuss the eighteen bird pictures. Bring out the concept that each adaptation helps the bird compete successfully in the niche it occupies. Page L-5 describes the birds' beaks and feet and gives the most obvious uses for which they are adapted.

After most of the students know what adaptations, niches, and competition mean, have each student answer question one, then discuss their answers as a class. Following the discussion, have the students review questions two and three, then start the film.

Run the film until the fight between the bull frog and the garter snake has concluded. Stop the film. Ask each student to try to list at least four adaptations shown in the early part of the film, and to give a partial description of the dragon fly and bull frog niches as requested in questions two and three. Point out that more adaptations and further descriptions of the niches will be included in the rest of the film.

After most students have made some effort to answer questions two and three. Have each student read question four, then run the film to its conclusion. Have each student complete his answers to the questions, then review the questions in class.

Answers - Student Self-Test Questions

Q 1. List four adaptations necessary for a rat to survive and compete with other animals.

A A) the ability to eat many kinds of food enables the rat to find food in most environments. B) The strong social organization of the rat colonies helps keep down competition between rats so that more of their energy can be spent looking for food and caring for young. C) The rat's whiskers allow him to follow tunnels and measure opening sizes in the dark. D) The rat's teeth grow continuously so that he can chew wood and most other materials without fear of wearing out his teeth. E) The rat's bare tail allows him to jump between heights and to balance on narrow ledges. It also stays clean as he moves through garbage and other sticky materials.

Students will probably develop other adaptations, such as fur color, sense of smell and hearing, climbing and digging ability, and so on. Stress that <u>all</u> normal characteristics are adaptations for the lives rats live.

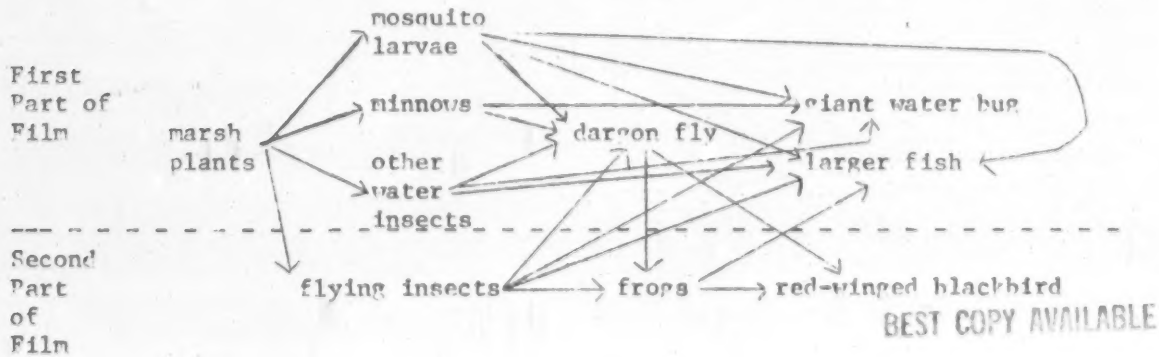
Q 2. List at least eight adaptations which allow marsh animals and plants to survive.

A Some of the adaptations shown in the <u>first</u> part of the film include: A) The spotted sandpiper able to walk on lily pads; B) Marsh flowers able to send roots to the bottom of the swamp; C) Muskrat nests built so that they will be surrounded by water (a behavioral adaptation). D) Snails, water mites, and painted turtles able to breathe on the surface and feed under water; D) Dragon fly nymphs with extremely quick jaws able to extend out and capture prey; E) Giant water bugs equipped with grasping forearms; and G) Bull frogs that puff up so that they look too big to eat or attack.

Some of the adaptations in the <u>latter</u> part of the film include: A) Resonating chambers on the frogs; B) The fact that dragon flies have a metamorphosis so that the adults can migrate easily, find mates, and select good sites for the eggs. C) The use of the dark for metamorphosis, since the dragon fly would be easy prey at this stage in daylight. D) The long legs, territorial behavior, and slow stalking of fish by the American Bittern and Blue Heron; E) The use of the male water bug's back as the depository for the female's eggs; F) The floating nest and good family organization of the grebe. Students should realize that physical characteristics and behavioral changes are both adaptations in most animals. Since behavior is largely instinctive, a genetic change is necessary for a significant change in behavior.

Q 3. Describe the marsh niches of dragon flies and bull frogs.

A The dragon flies' food web includes these <u>organisms</u> (most are in the film).



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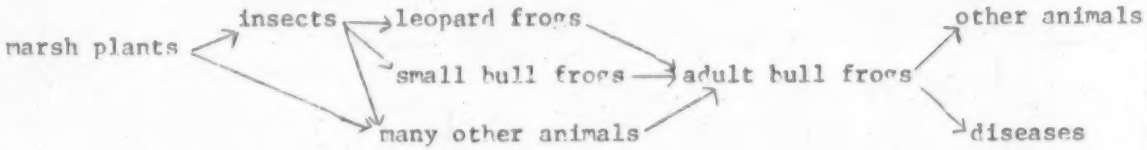
The niche also includes these behaviors. the dragon fly nymph spends over a year crawling under water on marsh grasses as it preys on water animals; the nymph crawls above water during the night to turn into a dragon fly. the dragon fly lives only a few weeks, and captures flying insects during that time. black birds eat both dragon flies and their eggs. eggs are carefully laid above water and below water on many blades of swamp grass so that consumers will have a difficult time eating every egg.

The niche also includes the swamp's physical environment. This environment includes brackish, shallow water, dry summers and moist winters, and so on.

The bull frog's food web includes these organisms:



The bull frog niche also includes these behaviors: the male bull frogs compete for a specific territory during mating season: each territory in the swamp may have one large batch of eggs laid in it, this makes sure that all eggs are not laid close together; frogs spend their early life under water as tadpoles. large frogs eat almost anything smaller than them, including small bull frogs; loud croaks help bring male and female frogs together during the mating season.

The environment for the bull frogs is much the same as for the dragon flies, except that the frogs spend more of their time above water and on the edge of the land at water's edge.

Q 4. Why must grebes and bull frogs lay such different numbers of eggs in order to survive? Give at least three reasons for the differences.

A Grebes only lay about five eggs because their nests are floating and protected from most predators. the family stays together and the parents protect and care for the young; there are few predators and plenty of food for the grebes in a marsh environment.

The bull frogs must lay thousands of eggs because the eggs are not protected and many animals eat them; the tadpoles are eaten by several water animals, including adult frogs; the tadpoles must survive for over a year before becoming bull frogs. the young frogs are eaten by many larger animals, including bull frogs, snakes, and birds.

In short, the bull frog has very strong competition from itself and from other organisms. The grebes have less competition, and need produce fewer offspring to survive as a species.

Note: Following the discussions of the Self-Test Questions, review the concepts stressed in this paper. Be sure to drive these points home: 1) All differences between species - physical and behavioral - represent adaptation, unless they happen to be new mutations with little adaptive value. 2) Niches include the animal's behavior, foods, predators, physical environment, and home requirements: in other words, its way of life: and 3) The only characteristics which become adaptations are those which allow the organism to produce offspring able to reproduce. No other characteristics have adaptive value, since they will not be passed on to future generations.

The film, Evolution, would be an enjoyable film to show at this point. It takes a rather irreverant look at evolution, survival of the fittest, adaptive radiation and so on. However, only good students with a basic understanding of evolutionary theory will enjoy and profit from the film. Most students will simply enjoy the film for its characters, action, and music. They probably will not be able to understand its content.

The papers "Why Robin's Lay Blue Eggs" and "Safety in Numbers" (pages 24-26) may also be worth discussing at this time.

Adaptations: Their Causes and Results

Successful adaptations have four characteristics:

1. They are caused by mutations, or changes, in the genes of a population of animals.

2. The mutations cause changes in the organism's physical, chemical, or behavioral characteristics.

3. The changes allow the organisms and their offspring to reproduce more successfully than their competitors. This is called survival of the fit.

4. In each generation, the organisms with the new adaptation make up a larger proportion of the population. This slow change is called natural selection.

About Mutations

One thing should be noted here: most mutations are not successful. A useful analogy can be made about mutations.

> If you tried to fix a watch that lost two minutes per day by blindfolding yourself and using a screwdriver to push or turn something in the workings of the watch, your watch would probably become even less accurate. However, one time in a thousand, or even a million attempts, you might improve the watch.

Your body is like a nearly perfect watch, and mutations are like the blindfolded watch repairman. Most mutations will not improve the genes the organism already has.

The second thing that should be noted about mutations is that they are very, very common. On the average, every gene has a one in 100,000 chance of mutating each time a cell divides. Scientific measurements indicate that our body has about 50,000 genes. This means that every newly conceived human has a 1/100,000 x 50,000 = 1/2 a chance of having a brand new mutation. In other words, for every 100 babies conceived, you would expect to find at least 50 brand new genes. Many of those new mutations are fatal. Out of every 100 babies conceived, ten will abort naturally because lethal genes have caused the fetus to be too deformed to live. Other mutations may hurt the organism, but still be passed on for generations. Color blindness is an example of a damaging but not lethal gene that can be inherited. Other mutations can be very helpful, such as those providing better brains, muscles, or lungs.

Natural Selection

The easiest way to understand the concept of natural selection is to study man's work with animals and plants. Wheat has been selected from grass; great Danes and toy terriers have been selected from animals much like wolves; Holstein milk cows and Hereford beef cows have both come from primitive cow-like animals. All of these organisms now exist because man has spent about 5,000 years raising and breeding the animals with the best adaptations. Our efforts meant that the best adaptations were encouraged to breed and reproduce in larger quantities than the rest of the competing organisms. Every generation helped develop an organism better fit for our purposes.

Nature acts like man, by allowing the reproduction of more organisms with favorable adaptations. Each generation, the organisms able to find the most food, the best homes, and the least enemies survive and reproduce. On the average, other organisms do not survive, or do not reproduce as successfully. It takes nature much longer than man to cause changes, since even the best adaptations are likely to be eaten and chance plays a big role in survival. However, man has been practicing selection only about 5,000 years. Nature has been working for at least 2,000,000,000 years.

Two Final Concepts

When nature, or man, has added so many new adaptations to the original organism that it could no longer be mated with the parent population, a new species is born. Wheat can no longer be fertilized with pollen from the wild grass from which it was created. Donkeys and horses cannot produce fertile offspring, though both arose from the same ancestors. Wheat, donkeys, and horses are all new species. In nature, each new species occupies a new niche, has different sets of foods and enemies.

When several new species originate from an original population, that is called adaptive radiation. For instance, every amphibian, reptile, mammal, and bird can trace their fossil history back to the early lung fish. These fish had an adaptation which allowed them to exist for brief times out of water. Over the 300,000,000 generations since those lung fish first appeared, trillions of new mutations allowed nature to select the combinations of adaptations that make up animals living today.

The diagram on page M-3 provides a summary of this paper. The film, "Darwin and the Theory of Natural Selection," also provides a review of these concepts.

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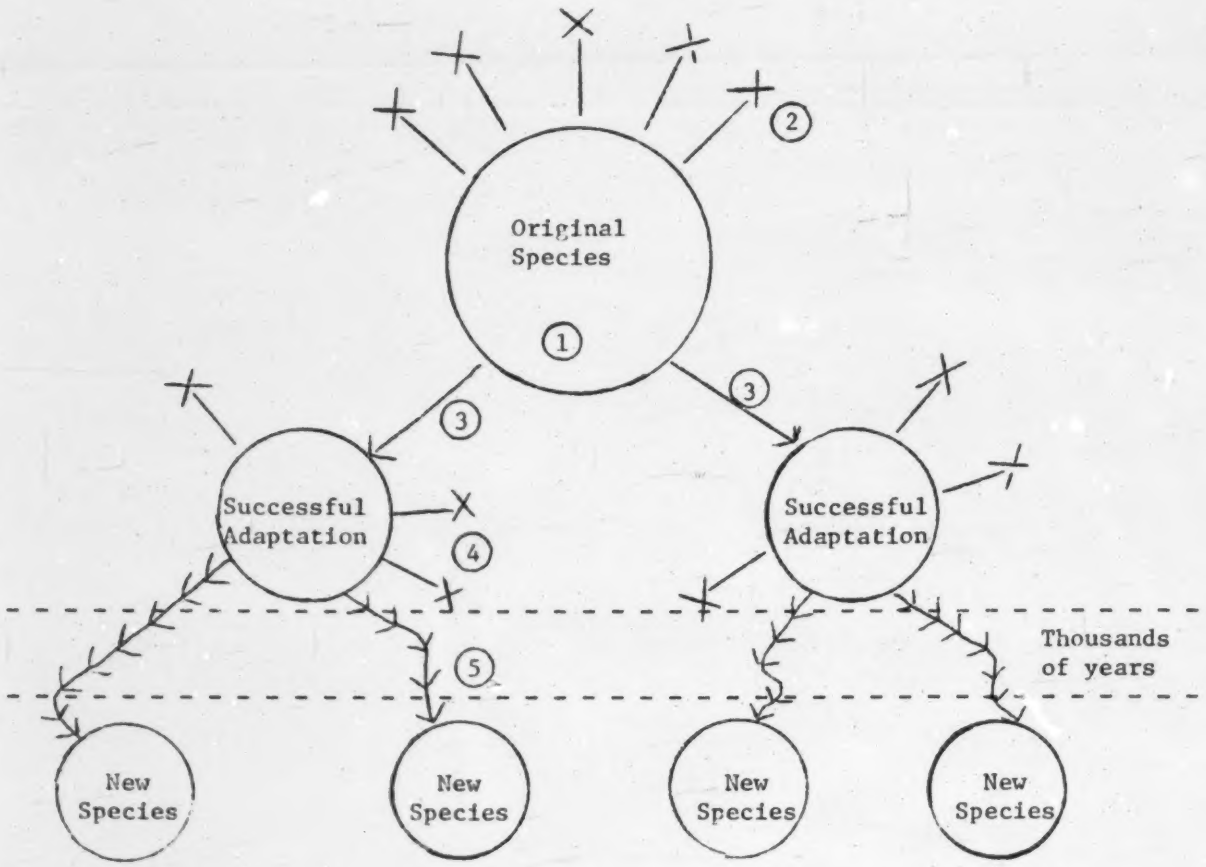
Summary Diagram of Adaptive Radiation



1. The original population has many mutations.

2. Most mutations do not cause adaptations.

3. A few mutations improve the ability of the organisms to survive. These are adaptations.

4. Because populations occur over wide areas, more than one adaptation can occur at once.

5. As much time passes, more adaptations occur, and eventually many new species occupying new niches are created from the original population.

STUDENT SELF-TEST

1. List at least four characteristics of Galapagos Island finches that show major adaptive changes.

2. What is meant by the statement, "If a niche exists, some population will adapt until it can fill it"?

3. How does nature determine which animals are the most fit?

Behavioral Objective Number	Topics and Concepts
3	Given a hypothetical problem, students shall indicate that animals and plants on both side of a new land bridge will undergo population changes.
10	Students shall be able to apply the concept "the normal fate of most species is extinction," to a specific problem.
11	Given a series of graphs, students shall be able to select the one indicating an increasing diversity of animal and plant species in the world in recent eras.
26	Students shall be able to apply the concept, "successful animals and plants usually alter their environment until they are no longer as successful," to a specific problem.
28	Students shall be able to apply the concept "all differences between species represent adaptations for survival in the niches occupied by the species" to a specific animal.
29	Students shall be able to apply the definition of "niche" to select the information required to best define an animal's niche.
30	Students shall be able to use the law "survival of the fittest" to select the most essential characteristic of a mutation with adaptive value.
31	Students shall be able to apply the concept, "organisms are fit only when many generations of their offspring can reproduce successfully" in evaluating the successful human society.
37	Match a biome with three adaptations unique to the animals of that area.
39	Students shall be able to match a biome with three adaptations unique to the plants of the area.
44	Students shall be able to apply the concept, "animal species with high mortality rates tend to produce many young which require little care," to a specific problem.

Teacher Suggestions

Have the students read Paper M, then use the discussion questions below.

1. If one coyote had a mutation which allowed it to run slightly faster, would this become an adaptation?

Answer: Perhaps - work to help the students understand that even a good mutation may not really help the organism. In this case, three other requirements would need to be satisfied for the mutation to become an adaptation. 1) Does the greater speed better enable the coyote to capture more prey? Many of the rabbits and mice it preys on run in zig-zags, and greater speed may not help the coyote. 2) Does the mutation hurt any adaptations that enable the coyote to breed successfully (i.e., does it change its appeal to the opposite sex, or does the mutation also affect the coyote's fertility)? 3) Does chance prevent the coyote with the first mutation from living to reproduce? If a hunter shoots the coyote or it breaks a leg and starves to death: the mutated gene could not be passed on. In other words, a gene has no adaptive value unless an animal's offspring are better able to reproduce compared with their competitors.

2. There is a rule in biology which says: "Two species can never occupy the same niche under natural conditions." Why would this rule be true?

Answer: If two organisms occupy the same nesting place, eat the same food, and have the same enemies, one will always be, or become, slightly better adapted and will reproduce more successfully every year until the less well-adapted species is extinct or has enough mutations to develop a new niche (i.e. - adaptations could allow the competing species to eat different foods, use different nesting sites, or elude old enemies).

Two organisms occupying similar niches are often thrown together when a land bridge connects two areas that have developed separate species. A classic example occurred in Australia when rabbits were introduced by man. The rabbits occupied the same niche as the native kangaroo and were better able to avoid predators and to utilize the grasses of Australia. The rabbits were eating so much of Australia's grass that the kangaroos (and man's sheep) were dying of starvation. Man finally changed the rabbit's niche by introducing a new disease that affected rabbits but not kangaroos. The disease controlled the rabbit's population and allowed both kangaroos and rabbits to survive in different niches.

Show Darwin and the Theory of Natural Selection

Stop the film after it explains the adaptations of the finches and shows a painting of trees with a pair of finches beginning to reproduce. Have the students answer question one. Then show the rest of the film.

Following the film, use these questions for a brief review:

1. If most organisms can adapt successfully, why do most species become extinct?

Answer: Most species become extinct because they adapt so much that they become a new species, or several new species, occupying new niches.

2. Why will the number of species keep growing larger and larger?

Answer: Because each species adapts to changing conditions, and conditions in different areas change differently. Therefore, new niches continue to develop and adaptive radiation produces new species to fill those niches.

3. Why do mice have large families which do not require too much care, while coyotes have small families which require much care?

Answer: Mice are killed so frequently that only mice able to leave large families produce enough offspring to allow any to reproduce. Coyotes, on the other hand have so much trouble finding food, that large families would result in starvation. Therefore, small families have an adaptive advantage.

4. What types of adaptations would be useful to plants and animals in a desert? Middle latitude grassland? Coniferous forest? Deciduous forest?

Answer: Work to get suggestions from all students. Even the slowest students can suggest some adaptations. Try to bring these out.

Desert Adaptations: Water retention, heat resistance, nocturnal activity.
Middle Latitude Grassland: Speed, burrowing ability, keen eyesight, good root structure, ability to withstand fire.
Coniferous Forest: Winter survival talents (hibernating, ability to move over snow). Ability to eat pine needles, ability to shed snow.
Deciduous Forest: Ability to eat tree leaves, hide when leaves are off and when on, produce leaves after frosts, reach light at high levels.

Answers - Student Self-Test Questions

Q 1. List at least four characteristics of Galapagos Island finches that show major adaptive changes.

A Color of the bird; bill size and shape; where the finch lives and hunts food (high or low in the trees); what food is eaten; and size of the bird are all characteristics which vary from species to species.

Q 2. What is meant by the statement, "If a niche exists, some population will adapt until it can fill it"?

A Discuss the question with the class. It means that if there is any place in nature where a good source of food is not being used, or a type of well protected home is not being used, mutations will occur that allow organisms living in similar niches to take advantage of the new niche. In other words - if a bush has a mutation which makes it taste bitter to the animals that used to eat it, then a new food source is available to animals able to eat the bitter bush.

The law says that, before long, some animals will have a mutation which allows them to eat the bitter tasting bush. The bush and the animal will become members of a new niche.

In practice, this means that every successful adaptation causes other organisms to adapt until they can take advantage of the original change.

Q 3. How does nature determine which animals are the most fit?

A If the animal is fit, it lives to reproduce and its offspring live to reproduce. If the animal is not fit, it, or its offspring, do not live to reproduce. That is how nature determines which animals are the most fit. Chance may kill a few fit organisms, but in the long run, more fit than unfit always reproduce.

Note: Some students may take this argument to mean that man should not try to limit his population growth because the fit should be allowed to compete. A major fallacy in this argument is that, if man's rapid reproduction destroys his niche, then his offspring cannot live to reproduce. In that case, high reproduction rates are not adaptive. This is why birds may lay only a few eggs, cows only have one calf a year and so on. More reproduction would destroy all young through starvation.

The Future: What Does It Offer?

Life today is the product of billions of years of ever-changing land forms, weather patterns, plants, and animals. Today, the world holds millions of species of plants and animals engaged in a never-ending fight to survive and to reproduce. Here and there, a species with a new and powerful adaptation will arise and reproduce rapidly. As it reproduces, its success changes the environment until other organisms change and meet the challenge.

Man is one of those new species with an unusually powerful adaptation--intelligence far greater than that of any other land animal. Through the use of his intelligence, man has improved his own efficiency and power in just hundreds, and recently, in just tens of years. In nature, the only animals able to change naturally at that rate are insects and disease organisms. Thus, man has created change so quickly that most natural forces have not been able to keep up.

Early man helped bring about the extinction of hundreds of large animals, such as the mammoth, the giant bison and the ground sloth. Modern man has expanded his niche into every continent in the world. We have wheat fields where desert, grassland, deciduous forest, and coniferous forest biomes once existed. Our cows have replaced bison, antelope, zebras, and kangaroos in environments throughout the world. Few plants or animals in the world have a population nearly the same as they held just 300 years ago. In short, man has drastically altered and reduced the food webs in nearly every biome of the world.

Natural Food Webs - Do They Matter?

In nature, a simple food web is always <u>less</u> stable than a complex web. For instance, in the Tundra biome, the food web is simple, since few species of plants and animals can survive the severe winters. An unusually bad winter in the tundra will cause much lower populations of lemmings and lower populations of the foxes that eat the lemmings. This in turn sets up that biome for a really good lichen and moss crop during the next few years; the lemming population would boom; and then the fox population would boom. The whole chain would then lose population again as too many lemmings ate too many plants, and the starving lemmings were eaten by the foxes.

The graphs on page two show how the populations change for animals and plants in a simple food web.

BEST COPY AVAILABLE

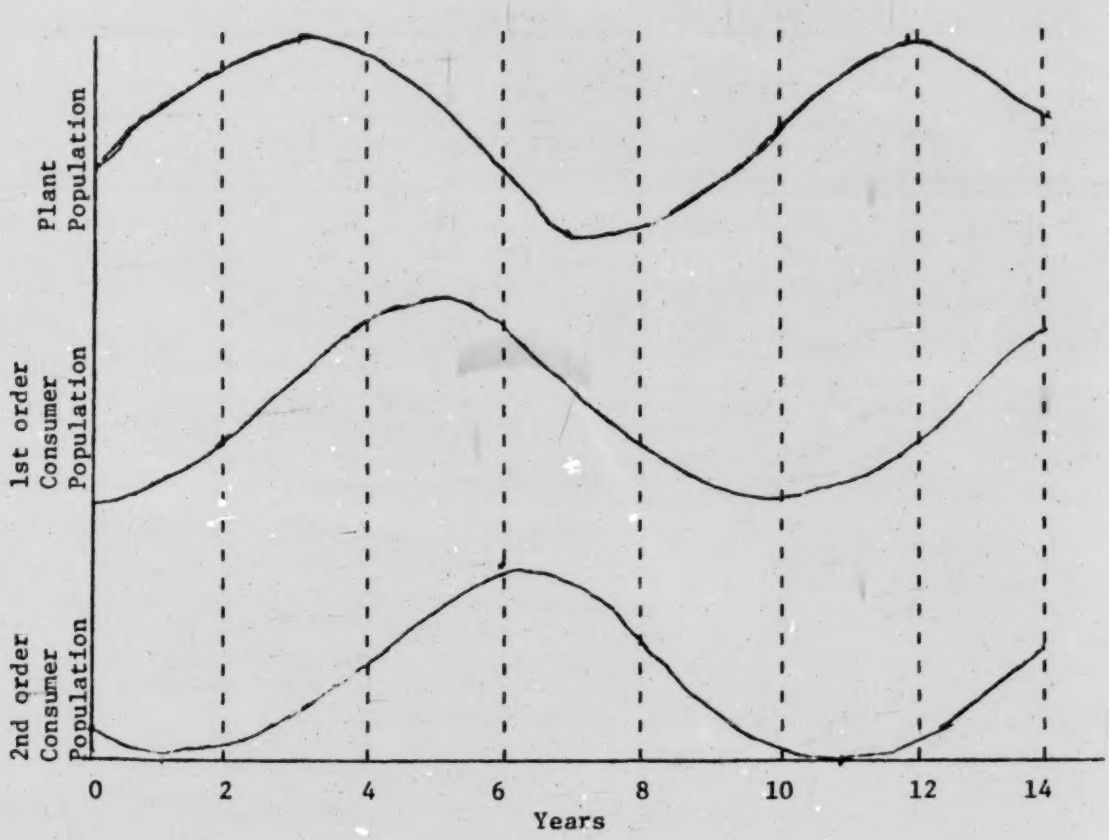


Figure 1. Population cycles in a simple food web.

The tropical biomes have a tremendous variety of animals and plants and very complex food webs. If one insect or bird begins to have a rapid population increase, then other birds, monkeys, and snakes quickly spend more time eating the newly available food. The population is quickly reduced to earlier levels and the many consumers begin to return to other kinds of food. In other words, the more kinds of consumers and producers, the more stable the populations of all species in the food web.

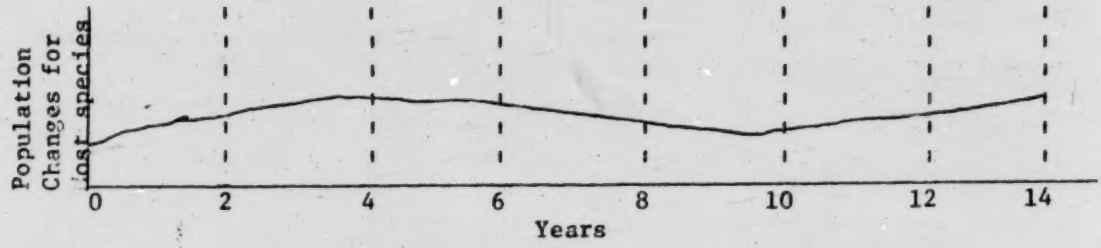


Figure 2. Population cycles for most organisms in a complex food web.

It is easy to accept the observations about food webs shown in the graphs above. However, when four additional facts are added to those graphs, the ideas aren't so easy to accept for man.

1. Man has been working for years to simplify his own food web. Most of us now eat foods from no more than 20 kinds of plants and animals, and only a few diseases can seriously affect our health. Early man ate hundreds of different plants and animals, and was eaten by many insects, diseases, and larger predators.

2. Only by simplifying our food web are we able to increase our population. If we still allowed hundreds of plants and insects to compete with our wheat and corn crops, we could not raise enough food to feed us all. If we allowed smallpox, polio, diphtheria, and large predators to consume us, we would have our population reduced. Our rapid population increase over the last 100 years is due to a tremendous simplification of our own food web.

3. A simple food web can be easily broken. If an organism depends on only a few kinds of food, and one source is destroyed, the organisms' population will suffer. We plant fields and fields of corn and wheat and crowd the thousands of cattle into small areas. With man, and our food supplies, tightly crowded, we invite new and better adapted diseases to sweep through our food supplies and our cities. A few years ago, a new corn disease began to move across our nation. Yields of corn plummeted, the cost of corn rose, the number of corn-fed animals declined, and our supplies of both meat and corn were threatened. A researcher just happened to have been working for years on a type of corn with very strong resistance to a very similar disease. Only his very lucky and good research, good weather, and our ability to rapidly grow the new and stronger corn seed in the Bahamas saved our corn the following year. A slightly different disease may have turned our economy upside down. The threat of new diseases will continue to increase as our population increases and our food surpluses continue to shrink.

4. Whenever an organism has a population explosion, his whole niche suffers. Gypsy moths are now killing trees, starving other insects, and destroying forest floor communities as their exploding population surges through Eastern United States. When their population is brought under control, millions of gypsy moths will not live to reproduce and many other organisms will find their populations rapidly changing. It will be many years before forests once again obtain balanced and stable food webs.

   Man's population throughout the world is still exploding. If nature fights back with a better adapted disease or insect that can affect us, our livestock, or our crops directly, billions of people and niches throughout the world could be destroyed as we frantically try to use every available acre to grow food for starving men.

Adaptations: Need They Concern Us?

Man's intelligence allows us to change much quicker than we could adapt through mutations. However, adaptations play a large role in creating problems for man's food webs.

Most animals eat, mate, and nest primarily by intuition. To change even the smallest aspect of an animal population's behavior or bodies requires a minimum of 20 generations. Twenty generations for man is 400 years; for wheat it's 20 years, for rabbits, it's seven years; for insects, it may be two years; for diseases, it may be but days. Thus, the diseases and insects which affect us and our crops can change much, much faster than we or our crops can.

As we change the world around us, most large animals and plants are unable to adapt to our changes. Their populations simply shrink and retreat. However, as we increase the populations of our domestic animals, plants, and us, the potential for adaptations among the parasites which prey on us is tremendous. We have been using insect sprays and most drugs for 30 years or less. In that 30 years, many insects have become immune to most of our early sprays. During that same time, the tolerance of the birds and mammals which eat the insects and drink the water containing those sprays has not increased at all. This is the major reason for banning DDT and many other poisonous, and now ineffective, insecticides.

Many diseases have developed resistance to many of our early drugs, such as penicillin and streptomycin. We must now use more potent, dangerous, and costly drugs to treat the newly adapted diseases. Thus, man is engaged in a war of our research against the genetic adaptability of bacteria, viruses, and fungi which prey on us and our domestic plants and animals. This war will never stop, for it takes man at least 10 years to prepare a new drug for a disease. It takes the disease less than a year to begin to develop resistance to the drug, so our efforts to develop better drugs causes stronger and stronger diseases to appear. We now have syphilis that is 100 times more resistant to penicillin than syphilis was 10 years ago. In 10 more years, syphilis will probably be nearly immune to penicillin and only drugs stronger and more dangerous to man will be useful.

Energy Makes Our World Tick

Energy is used to grow food, build homes, run factories, and carry food from where it's grown to the cities. Almost all of that energy was captured from the sun and stored by plants more than 100 million years ago. Men throughout the world are rapidly using that energy, and over the next century the energy crisis will almost certainly cause tremendous changes in the way we live. Many people continue to waste energy, hoping that nuclear power, or solar power will be developed before the world's oil, coal, and natural gas are burned up. Farsighted people must wonder what will happen if we discover that no good alternative to petroleum products can be used to power the engines that grow our food and deliver it to the cities.

Reproduction - Nature's Command

Throughout this module, it has been shown that only those organisms that can reproduce will survive. The fit, are the organisms that can thrive and produce young.

On the other hand, man's reproduction rate is rapidly increasing the possibility that starvation, disease, or wars over available supplies of oil and coal, may destroy most of our population and those of the animals and plants around us.

Thus, most young people are caught between two opposing forces armed with powerful weapons. One force argues that the only logical thing to do is to have as many young as possible for that is nature's way. They reason that nature will control our population just as other natural populations are controlled. The individual would be foolish to limit his family and allow others to reproduce.

The opposite side argues that the very difference between man and other organisms--our intelligence--should be used to control our population growth before nature uses its three big weapons--starvation, disease, and competition (war), to control our growth.

Two extremely important differences between natural and man-controlled societies should be made. In nature, the fit individual survives and reproduces, and whether or not it survives is mostly due to chance and its own ability to find food, fight, escape, etc. In man's world, the fit society survives, and the fitness of the society is mostly determined by the intelligence of the people, their technology, and energy resources. Reducing man's population may allow better technology and more energy to be used for the good of everyone in the society. If each individual has as many children as possible, society may weaken and destroy the very protection which allowed its members to have so many children in the first place.

Can You Help Your Children's Children?

No matter how you feel about population growth, you can do four things to help make the world better for all people.

1. Support scientific research. Information from science may sometimes cause damage, but our only hope to control diseases of people and the organisms we eat lies in continuous research of all types. We know that any drug, spray, or resistant species of plant or animal will soon be obsolete due to the rapid changes in insects and germs. Only research done long before the organisms actually mutate will allow us to react fast enough to stop a catastrophe.

2. Use less energy. Everytime you use electricity, gasoline, or any other kind of energy produced from fossil fuel, you permanently destroy a little more of the energy nature stored hundreds of millions of years ago. We may develop a good substitute that can power our cars and trucks, but what if we don't?

3. Waste as little as possible. Try to recycle metals and paper, for supplies of many metal ores and trees will get much lower if our population continues to grow.

4. Keep track of changes in the world around you, and let others know when you see them making mistakes that may destroy our world. People should not sit on their hands while budgets for medical and agriculture research are cut and millions of pounds of copper, tin, and wood are daily thrown away. As we use up the resources provided by nature, we are only increasing the chance that our children will be miserable. For the good of us all - learn, observe, and react!

STUDENT SELF-TEST

1. Why is a complex food web more stable than a simple food web?

2. List four ways that human population growth has changed the world around us.

3. Why do some organisms adapt much faster than others?

4. Two rules of nature have always been true:

   1) Successful organisms always change their environment until they are no longer successful.

   2) All species will either adapt to a changing world, or become extinct.

   Do you think man will obey those rules? Why?

Behavioral Objective Number	Topics and Concepts
10	Students shall be able to apply the concept, "the normal fate for most species is extinction," to a specific problem.
13	Students shall indicate that much of the energy we use today was stored millions of years ago by plants.
20	Given a food chain, students shall be able to select a population that would increase as a result of a decrease in another animal's population within the food chain.
25	Students shall indicate that succession moves from simple to complex food chains.
26	Students shall be able to apply the concept, "successful animals and plants usually alter their environment until they are no longer successful," to a specific problem.
30	Students shall be able to use the law "Survival of the Fittest," to select the most essential characteristic of a mutation with adaptive value.
31	Students shall be able to apply the concept "Organisms are fit only when many generations of their offspring can reproduce successfully," in evaluating the successful human society.
32	Students shall apply the two concepts "control by society is essential if the environment is to be managed properly, for the individual who abuses the environment gains most of the advantage, while all of society shares the loss," and "humans should strive to leave future generations the social structure, resources, and environmental quality required for lives as fulfilling as our own" to 10 specific areas of conflicting value judgments.

Teacher Suggestions

This paper should be presented immediately before, after, or in the same periods with the film, Tragedy of the Commons." In discussing the paper with your class, try to review each of the concepts listed above.

A good class discussion of the student self-test questions, the paper, and the questions from the "Tragedy of the Commons" should adequately meet the objectives for this paper.

Answers - Student Self-Test Questions

Q 1. Why is a complex food web more stable than a simple food web?

A In a complex food web, every organism has several other animals eating it and/or it eats a wide variety of plants and animals. As the population of any organism increases or decreases, the many animals and plants in its niche react to keep the population stable.

In a simple food chain, a rapid population change of one organism may overwhelm its food supply, or may require several generations for its predators to increase enough to control it.

Q 2. List four ways that human population growth has changed the world around us.

A We have changed the native plant and animal populations throughout the world; we may be changing the world's climate; we have used much of the world's fossil fuel; we have polluted the streams; and we have wasted many minerals.

Q 3. Why do some organisms adapt much faster than others?

A Adaptation rates are strongly dependent on the length of time for each generation. Organisms requiring little time to reproduce (bacteria) will adapt much faster than animals with long periods of time between new generations.

Q 4. Two rules of nature have always been true:

1) Successful organisms always change their environment until they are no longer successful.

2) All species will either adapt to a changing world, or become extinct.

Do you think man will obey those rules? Why?

A Discuss this question with the class. It's really too early to tell if man will obey those rules, but in all probability he will. The thing man must work for is adaptation, not extinction of our offspring. Careful thought before making changes in the world around us will help us survive as a species, and applying knowledge wisely is a form of behavioral adaptation.

The film, Tragedy of the Commons' is a film for far-sighted and thinking humans. It presents some facts and ideas which are hard for many people to face calmly. Many of the questions it raises about our future cannot be answered with a simple 'yes' or 'no', but require a 'maybe, if _____'.

Three broad concepts are presented in this film:

1) The world must be viewed as a commons, which we share with all other living and yet to be born humans. If we kill the last of any species of plants or animals, no humans will ever again see that organism. Every chunk of coal or drop of oil we use will never again be available for future humans. If we allow land to erode, soil will not regain its value for thousands of years. If we change the world's climate, every biome in the world may be changed in unpredictable ways.

   In other words, our present actions as individuals and as a society will help determine the quality of life in the future for ourselves and our offspring.

2) The more dense the human population becomes, the more eligible it is for disaster.

   As people crowd together, their freedoms must be restricted if all are to continue to live. Psychologically we wall out other people, and we are walled out. Others become not people, but things to be cheated, hurt, and ignored since their lives mean nothing to ours. Government protects each of us from others with laws which restrict freedoms enjoyed by people in less crowded societies.

   To maintain a crowded population requires much energy to import food, power industry, and remove concentrated air and water pollution. If energy is not available, the quality of life deteriorates quickly.

   Disease is given the best possible conditions to mutate into new forms and to spread rapidly from human to human in a crowded environment.

3) We cannot maximize both population and quality of life!

   The world's resources are limited. As the human population grows, places to take vacations, rights to individual attention, amounts of oil, water, metal, wood, food, etc. decrease for each person.

   The world's population is now so big that everyone could not possibly have the standard of living of Americans. There is not enough energy, metal, and food for others to equal our wealth. If the world's population continues to expand, our ability to buy inexpensive food, plentiful fuel, and a quality life will decrease.

   The film does not give nice and neatly packaged answers to the problems it raises. Some of its theories and observations may be contested, but if it is correct in its viewpoint, then values of all people everywhere must change if we are to become a truly 'fit' species. Governments at all levels will need to be staffed by people who can see beyond the next election and beyond their own generation. Fortunately, United States will have a large voice in determining the future of the world, and each of us still has a voice in our government. Our actions will determine if we are alive to receive praise, or abuse, from our grandchildren.

STUDENT SELF-TEST

Tragedy of the Commons (Part I)

1. Would you have acted as the herdsmen did? Why?

2. Who should be responsible for commons? Why?

3. Do we have any commons in the world today? Where?

Tragedy of the Commons (Part II)

4. Do you think Dr. Hardin was right when he said, "We wall out people when we are in crowds"? Provide evidence for your position.

5. What did the scenes with the girl singing "Everyone I See Has A Smile For Me" mean to you?

6. Did you notice any new ideas about man's use of the commons?

Tragedy of the Commons (Part III)

7. What freedoms do you lose by living in a very crowded city? What freedoms are gained?

8. Should anyone be able to tell a farmer, "Terrace your land to stop erosion, or we'll make you sell your land to someone else"? Should someone be able to tell you, "You can only have this much electricity this year. We must save our coal for future generations"? Why do you answer as you do?

9. What causes people to feel differently and have different ideas about large cities and over population?

Tragedy of the Commons (Part IV)

10. What solutions does this part of the film offer for problems raised during the first three parts?

11. Who should decide how many people should be born?

12. How does nature control population?

Behaviroal Objective Number	Topics and Concepts
30	Students shall be able to use the law "Survival of the Fittest" to select the most essential characteristic of a mutation with adaptive value.
31	Students shall be able to apply the concept "Organisms are fit only when many generations of their offspring can reproduce successfully" in evaluating the successful human society.
32	Apply the two concepts "control by society is essential if the environment is to be managed properly, for the individual who abuses the environment gains most of the advantage, while all of society shares the loss;" and "humans should strive to leave future generations the social structure, resources, and environmental quality required for leading lives as fulfilling as our own" to 10 specific areas of conflicting value judgements.
33	Students shall be able to interpret the film Tragedy of the Commons and select the best summary statement of the film's message.

Teacher Suggestions

Before showing this film, try to carefully read the entire "Instructional Guide" for the film, preview the film, and then take time to carefully think out the goals you would have for your class.

The film is the most powerful tool we have seen for stimulating class discussion about man's role in his world, but, showing the film without careful teacher preparation and thought is like using a scalpel for a screwdriver.

The thing that has worked very well for us has been breaking the class into groups of four or five students. Have each group spend five to ten minutes after each film segment discussing the student self-test questions. Then bring the class back together and solicit group answers, comments, and counter-comments.

If only the class as a whole discusses the film, many students will never express themselves. If only small groups discuss the film, students may never hear strong dissenting views. The best of both worlds can be achieved by having both levels of discussion.

Work to maintain a rational, not emotional, discussion. Act simply as a discussion leader who recognizes students, summarizes arguments, and tries to keep both sides of the many potential conflicts represented. The overall goal should be to force students to examine their present actions in the light of concern for people living now and in the future.

One correction should be made in the film if students ask. In part four, it presents a comparison of the growth rate of two and three-child families. The three-child increase should go in this fashion:

Parents	Children	Children's Share of Children		so on		
2	3	4.5	6.7	10.1	15.2	22.8

since each parent would produce the equivalent of 1.5 children per generation. In a similar vein, the two-child family would maintain its one child per parent average every generation, and its size would be 2-2-2-2-2.

The film correctly shows the growth of the two-child family, but incorrectly indicates that the three-child family would grow by an average of three children per parent, per generation. The conclusions reached would be the same, but the time would be much longer. Unless a student notices the error, it would probably be better to not explain the mistake, since you will be pressed for time anyway.

Answers - Film Questions for Tragedy of the Commons

There are no "right" answers for most questions about this film.

Your role in this film is to keep the class discussion balanced and as rational as possible. Act only as a director to call on students, and try to avoid saying anything, other than summarizing the total arguments presented on each question. The class should make its own decisions about the "right" answers to these questions. The instructional guide has some excellent suggestions for goals for each part of the film.

THE FIELD TRIP

Topics and Concepts

Behavioral objectives 4-12, 14 and 16-32 will all be reviewed during the trip, as guides follow the directions contained in this paper.

The following objectives are for new concepts introduced during the trip.

34. Students shall be able to select the best description of the bone arrangement of large animal fossils.

35. Students shall be able to select the class of modern animals most like the first vertebrates that left fossil remains.

36. Students shall be able to select the correct statement about physical changes occurring during the evolution of horses.

37. Students shall be able to match a biome with three adaptations unique to the animals of that area.

38. Students shall be able to select the source of most moisture received in Kansas.

39. Students shall be able to match a biome with three adaptations unique to the plants of the area.

40. Students shall be able to select the factors which most limit the populations of large carnivores.

41. Given a description of egg size and shape, students shall be able to select the probable nest location and chick maturity at hatching.

42. Students shall indicate that albino birds do not reproduce as successfully as other birds and have excessive feather wear.

43. Given descriptions of cowbird nesting, eating, and chick-care behaviors, students shall be able to select the incorrect statement.

44. Students shall be able to apply the concept "animal species with high mortality rates tend to produce young which require little care" to a specific problem.

THE TOPEKA PUBLIC SCHOOLS
REQUEST TO PRINCIPAL FOR FIELD TRIP
Secondary Schools

Community resources are valuable aids to the instructional program. Careful planning and proper follow-up are necessary in order to make the trip most worthwhile. This form should be properly completed in TRIPLICATE and signed by the teacher and principal. The original copy is filed in the principal's office. The principal shall send duplicates to the office of instruction and departmental supervisor.

School_____ Department Science Subject and Class_____

Date of Trip_____ Leave_____ Return_____ Number of Pupils_____

Description of Trip The class will study the University of Kansas Natural History Museum. The trip will last three and one-half hours. Students will be divided into groups of ten or fewer students and will be led by a trained guide.

Objectives of the Trip To provide concrete examples of concepts developed during the pre-trip and posttrip study of the "Life: Past, Present, and Future" module. All students will study the displays dealing with paleontology, biomes, and animal adaptations. The field trip experience will expand and reinforce concepts developed through class activities, papers, and films. Behavioral objectives, classroom material, field trip worksheets, and pre and posttrip tests were developed by the Environmental Education Project.

Means of Transportation Environmental Education bus

Required Student Cost none

Teacher Signature_____ Date_____

- - - -

The Topeka Public and Parochial Schools
Unified School District No. 501
Environmental Education Demonstration Project
Phone: 232-9374

The_____school science students in_____class will be participating in a three and one-half hour field trip through the Kansas University Natural History Museum on_____. For the past three weeks, the class has been studying paleontology, biomes, weather patterns, and animal adaptations. Transportation and trained leaders for the trip will be supplied by the federally funded Environmental Education Project.

If you give_____permission to take this trip, please answer the following questions, and give your signature below.

_____
Signature of Parent

Emergency Information:

Home Phone_____

Alternate Phone_____

Doctor's Name_____

Doctor's Phone_____

- - - -

Using Field Trip Forms

"Request to Principal for Field Trip" form.

Three copies of this form must be submitted for each field trip. They should be submitted as early as possible and at least one week prior to the trip. You may use the form on page P-2 in either of two ways: duplicate it the proper number of times, fill in the required information, and turn in to your principal; or obtain the proper number of request forms from your principal and transfer this information to it.

Please invite your principals to attend this trip with you. It will provide them a much better picture of the value of field trips than could be conveyed in any number of words.

"Parental Permission" forms.

Duplicate page P-3, and strongly urge your students to have their parents read and sign these sheets. They are quite important to the continued success of this project and in establishing some communication from you to the parents. We need the volunteers that are occasionally picked up with this form, and the community should be aware of what the project and its teachers are doing with their students. We also need the emergency phone numbers in case a student should be hurt.

Have the class fill out the first three blank lines before sending the forms home. Please bring the forms with you when boarding the bus.

"University of Kansas Museum Note Sheet" forms

Pages P-6 to P-11 will be given to students for use during the field trip by the project. In future years, these pages may be duplicated by the teacher.

After extensive trials, we have found that A) requiring students to take notes during the trip; B) taking up the worksheets following the trip; C) cursory checking of student effort; and D) using the worksheets for review has worked well for both student enjoyment and learning.

Planning for the Substitute: The substitute provided by our project is able to present Paper I, J, K. L, and M. She should not be expected to handle the film, Tragedy of the Commons and Paper N easily, since good knowledge of the students in the class is required to make this discussion profitable.

Provide the substitute with lesson plans for each class which would allow her to present meaningful and interesting material.

Notify both the substitute and the students of the various discipline tools at her disposal, for many classes prefer to harass rather than learn from a substitute.

Pre-trip Lecture Suggestions.

1. Remind students where they will meet the bus and the time for departure and return to the school.

2. Students will be walking outside for up to 15 minutes of the trip and will walk one mile during the trip, so they should have appropriate clothing and shoes.

3. Do not bring cameras, tape recorders, or other bulky items. They would add nothing to the museum visit, and may be stolen (as one was last year).

4. Bring pencils or pens. Students will be expected to take notes. The project supplies clipboards and work sheets.

5. Eat a nutritious breakfast and (in case of afternoon trips) lunch. Students with inadequate meals tire out quickly, and grumbling stomachs provide strong competition for constructive learning.

6. Smoking is not allowed on the bus (state law, flammable seats, and close quarters dictate this). Smoking is not allowed in the museum (their regulations). Smoking is allowed on the walk between the museum and the bus.

7. Behavior during the trip: a) Groups will be selected at random by the Environmental Education staff. This is to provide a good mixture of all types of students and interests in each group. In a mixed group, all members can share and learn more. b) The trip is an intensive learning experience, so come prepared to work and learn. c) Each group is to remain under the supervision of one guide for the entire trip. d) If a student cannot cooperate and work with other students and the guides, please tell the teacher now, and stay home. One disruptive student can damage the learning and appreciation of the trip for every other student in the group. e) If gasoline supplies are restricted too much, classes may need to be doubled up. We hope students will be tolerant. The gas usage per student is quite small, but the trip does require about 11 gallons of ga

Field Trip Time Line

The trip requires a full three and one-half hours to reach every objective. If four hours are available, the third floor will be visited in addition to floors one, two, and four. A 20-minute slide-tape presentation is available to show how the museum exhibits are made and how the museum works to help science. We strongly recommend its showing before taking the trip.

Travel to the museum and disembarking time	45 Minutes
Tour of the museum (40 minutes per floor).	2 Hours
Travel to the school and disembarking time	45 Minutes

Directions for Trip Guides

The field trip for each group will be unique. The class will be divided (arbitrarily) into groups of ten students or less. Each group will have a different leader and a different route, but all will try to meet the same basic goals. Guides will move in the floor sequence 1-2-4-1. Each guide will start at a different floor.

These suggestions should help make the field trip as profitable as possible.

1. Learn the students' names as quickly as possible, and call them by name throughout the trip.
2. Vary your topics and pace.
3. Do not talk to the group until all can hear and see what is being discussed.
4. Frequently ask a question, let students think awhile, then pick a specific student (on a semi-rotating basis) to answer the question. Keep questions moving and random enough that students never know who may be called upon next.

The list which follows describes the activities, allotted times, and suggested topics to be discussed at each point on the trip circuit.

UNIVERSITY OF KANSAS MUSEUM NOTE SHEET

Name_____

The questions on this sheet are those which will be on the test based on this trip. If you observe carefully, you should be able to answer most of the questions. There is room for you to jot down notes for yourself.

Guides who go with you on this trip will locate the exhibits for the questions below. They can help you with the answers, but you must do most of the thinking yourself.

Floor 1

1. Why is the large mosasaur in the central display case in an unrealistic position for a fossil?

2. Why are bird fossils the rarest of vertebrate fossils?

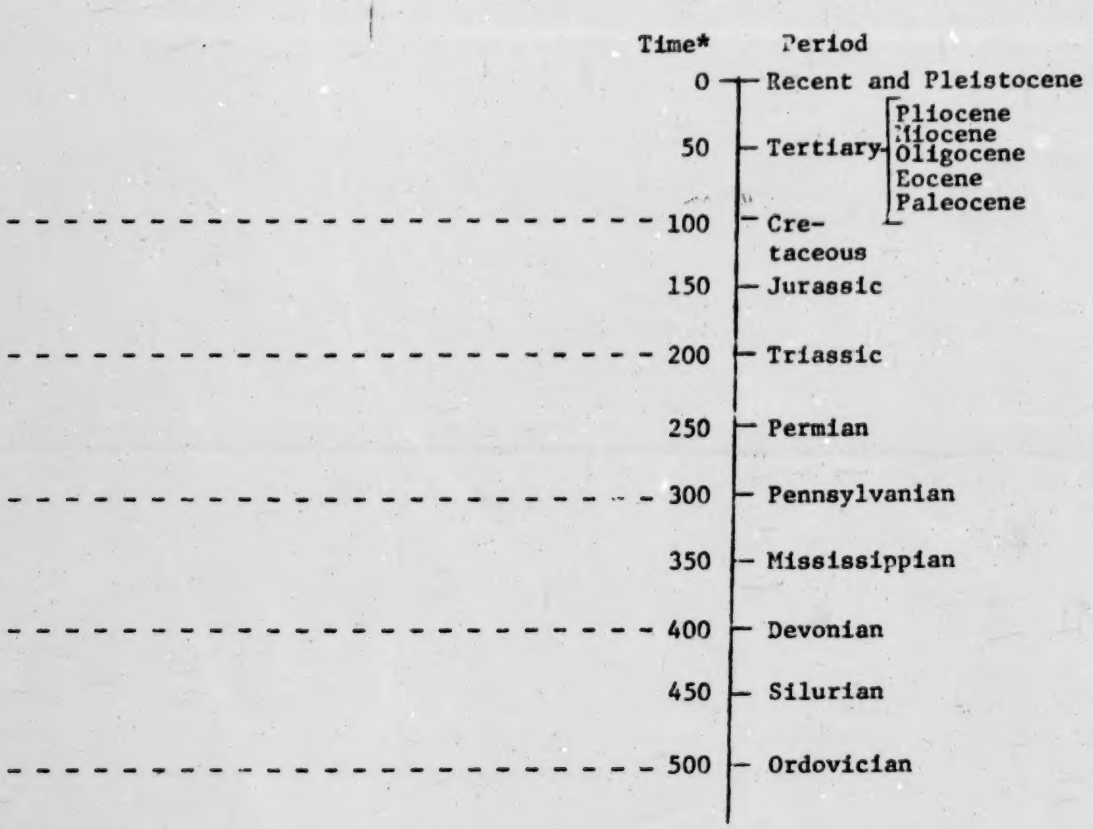
3. What happened to the size, teeth, and feet of the horse between the Eocene and Pleistocene?

4. What form did the horse's ancestor have during the Devonian Period?

5. Find two different displays showing fossils of many animals that died at the same time. What caused the death in each display?

6. What three characteristics are needed for something to be classified as a fossil?

7. In the spaces below, indicate when different kinds of backboned animals first appeared in the fossil record.



*Time is in millions of years since period began.

8. What portion of the earth's total history is contained in the chart above?

Floor 2

Try to find plant and animal adaptations and one food chain for each of these displays.

9. Tundra

   Plant adaptations _____

   Animal adaptations _____

   Food chain _____

10. Northern Coniferous Forest

   Plant adaptations _____

   Animal adaptations _____

   Food chain _____

11. Middle Latitude Deciduous Forest

   Plant adaptations _____

   Animal adaptations _____

   Food chain _____

12. Desert

   Plant adaptations _____

   Animal adaptations _____

   Food chain _____

13. Tropical Rain Forest

   Plant adaptations _____

   Animal adaptations _____

   Food chain _____

Floor 3 (Optional)

14. Would you expect the skulls in the display on the evolution of man to be real? Why?

15. When did early man first arrive in America?

16. Compare the common foods and tools used by the following three groups of early men when they lived in Kansas.

    Paleo and Archaic Indians:

    Woodland and Hopewellian Indians:

    Central Plains Farmers:

17. Have men always caused other animals to become extinct, or is this a recent trait? What evidence can you find to support your theory?

18. Were the societies whose artifacts are shown on this floor "worse" or lower than ours? Who should judge?

19. What fossil evidence would be needed in order to say that the center displays on ancient man were accurate, rather than merely possible?

Floor 4

20. Why is the cowbird called a parasite when it lives on seeds and insects?

21. Suggest two adaptations which would help birds avoid parasitism by cowbirds.

22. Of what use are owl pellets to ecologists?

23. Give two advantages that dark pigment gives to bird feathers and the bird.

24. How could insecticides destroy the yucca plant?

25. What advantage would birds gain by adapting to eating plants, not insects and animals?

26. What are three things which influence the number of eggs laid by one species of birds?

27. A medium-sized bird lays its eggs in holes in trees and has young which quickly leave the nest. Predict the color, size, and shape of its eggs.

Prediction	Reason for Prediction
Color	
Size	
Shape	

K.U. MUSEUM TEACHER AND VOLUNTEER WORKSHEET

The material below will provide some background for discussing the questions raised during the field trip. The trip guides are responsible for teaching the basic answers and laying the groundwork for understanding the larger concepts. The teachers are responsible for building on the material during a follow-up class discussion.

Floor 1

Suggested presentation method for this floor:

1. Let students wander the floor and look at the various exhibits for no more than five minutes. During this time, contact each student and learn his name.

2. Bring the students together facing the Mosasaur display, and discuss question one.

3. Proceed around the floor, stopping in front of the Devonian fish, Pennsylvanian amphibian, Permian reptile, Jurassic and Cretaceous dinosaur displays. Discuss the evolution of vertebrate animals illustrated in this sequence, and have students make notes on question seven.

4. Stop beside the Cretaceous bird fossil display and discuss question 2. Point out the teeth on early birds and ask what they must have eaten.

5. Continue to the mastodon and mammoth displays and have students determine the period of these mammals existence.

6. Discuss questions three and four in front of the display about the evolution of the horse.

7. Continue through the Pleistocene and recent displays, pointing out the importance of the extinct giant bison with the arrowhead in its shoulder, the giant camel and so on.

8. Facing the tar pit display, ask students to answer question five and six. Point out the tar pits and the display on fossils. Give the students five minutes to wander the floor and find their answers.

9. Bring the group together in front of the Wyoming fish kill, if possible, and discuss questions five, six, seven, and eight.

Total time = 40 minutes.

Floor 1.

Two broad concepts should be gained from this floor: many, many more animals used to live than are now living; evolution is a very slow, but continuous occurrence.

Q 1. Why is the large mosasaur in the central display case in an unrealistic position for a fossil?

A
1) The sedimentary deposits surrounding a fossil will be compressed from 10 to 100 times as rocks are formed from the mud or sand deposits. Therefore, fossils are usually crushed flat and in one plane.
2) Older rocks are located lower than newer rocks. This mosasaur's head would be thousands of years older than its tail.
3) Complete fossils with all parts in position are extremely rare.

Q 2. Why are bird fossils among the rarest of vertebrate fossils?

A Birds are able to fly away from most disasters; they live in wooded areas, where few fossils are made, have small fragile bones, good meat and are usually eaten; and they float so that they seldom sink to be covered with mud. Birds, therefore, leave very scanty fossil records. They are also rare because paleontologists frequently miss the delicate bones and feathers in fossils.

Q 3. What happened to the size, teeth, and feet of the horse between the Eocene and Pleistocene?

A The horse's feet went from four toes to one toe per foot.
Size went from two feet to five feet at the shoulders. This allowed them to better cope with predators.
Teeth went from short, tree leaf browsing teeth to long, grass chewing teeth.
In discussing this question, point out Figure 6, Paper D, Page 3. One hundred million years ago, there were no Rocky Mountains--just an ocean in that area. As the mountains rose, they changed the North American climate from damp forest to, in many areas, grassland. This slow mountain building encouraged adaptations in the horse.

Q 4. What form did the horse's ancestor have during the Devonian Period?

A The most advanced vertebrate at that time was a very primitive amphibian. Therefore, the horse's ancestor at that time would have been a primitive amphibian.

Q 5. What caused the death of animals in the two displays showing many different kinds of dead animals in one area?

A Four displays are possible for this answer.

The Wyoming Fish Kill was probably caused by water that became toxic because of drought, excess algae growth, or some source of natural poison.

The Crinoid Kill was probably caused by toxic water caused by algae growth or mud slides.

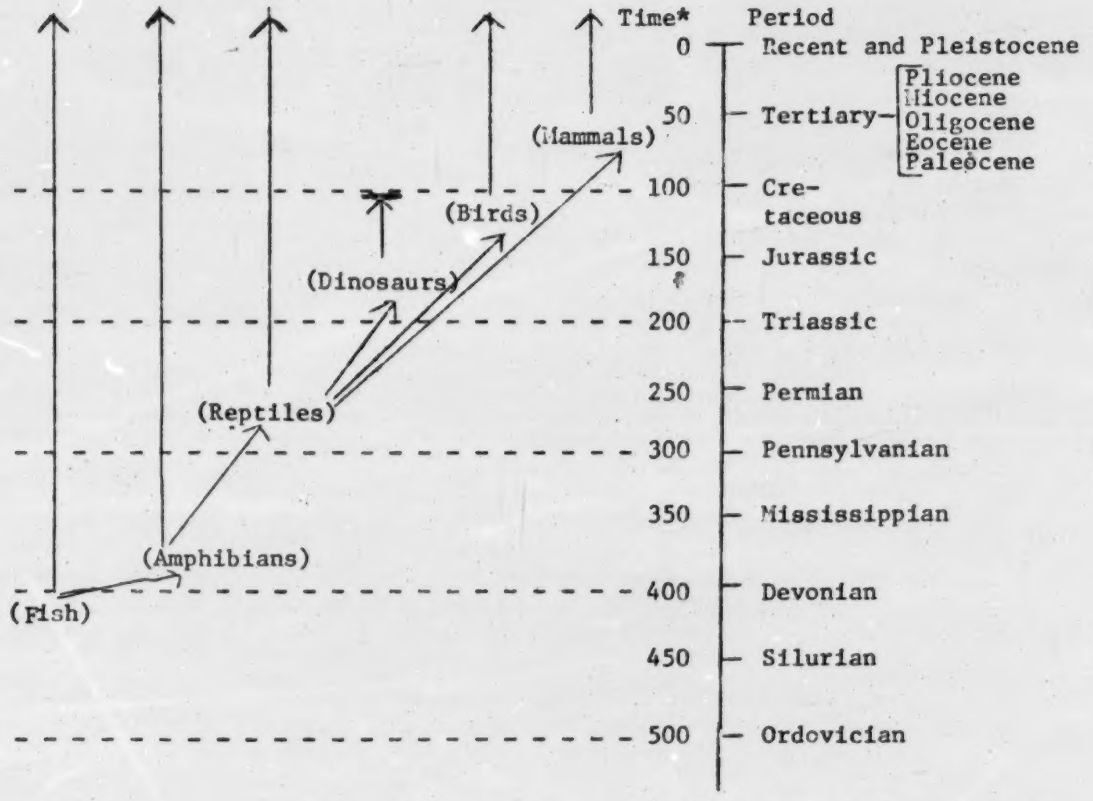
The Tar Pits trapped animals in tar saturated sand, which acts like quicksand.

The Agate Springs bone bed was probably caused by a flood and stream concentration of dead animals in one area.

Q 6. What three characteristics are needed for something to be classified as a fossil?

A Burial in the ground, organic origin (i.e. it had to be made by a living thing) and ancient origin.

Q 7. In the spaces below, indicate when different kinds of backboned animals first appeared in the fossil record.



*Time is in millions of years since period began.

A The animals in brackets indicate the first appearance of the classes of animals shown in the Natural History Museum. In the review session, you should point out that primitive mammals appeared in the Cretaceous and that all classes of animals have had some representatives survive up until now. You should also point out that the vast majority of all species of animals that once existed are now extinct.

Q 8. What portion of the earth's total history is contained in the chart above?

A Less than one tenth of the total time is represented on this chart. (The earth cooled from a molton state for three billion years before even algae appeared--this chart represents only one-half billion years.)

Floor 2

Five concepts should be emphasized on this floor: 1) life zones are controlled by both rainfall and temperatures, 2) man has drastically altered the middle latitude deciduous forest, and is beginning to change the other areas; 3) all animals and plants will exhibit many adaptations in order to survive; 4) all food chains depend on plants; and 5) parasites and starvation control the populations of most predators.

Suggested presentation method for floor 2:

1. Allow students to view the exhibits independently for five minutes.

2. Review Teacher Paper F, Page 6, discussion question 5, before discussing this material. Use the large North America map to review and discuss the topics below. Students should be able to identify where the different biomes are located and explain why the weather patterns exist as they do for the different areas. Ask these review questions:

   a. From which direction do winds usually blow? (From west to east)

   b. Why is there very little rainfall over the Southwestern United States? (The Pacific Coast Mountains catch moist air from the Pacific and moist air from the Gulf can seldom move against the prevailing wind direction for such long distances.)

   c. How do mountains remove moisture from the air? (The air cools as it goes over the mountains, and cool air cannot hold much moisture. Clouds and rain form as the air cools.)

   d. Why does Eastern Kansas receive more moisture than Western Kansas? (Moist Gulf winds are more likely to move east with prevailing winds.)

   e. Why does rain fall where there are no mountains to cool the air? (Cold fronts moving from the north cool the warm, moist air.)

   f. Which biome, Tundra, Coniferous Forest, or Deciduous Forest, receives the most moisture? (Deciduous Forest)

   g. Why? (Warm, moist air is most likely to be cooled over the middle latitudes. It seldom reaches the northern-most latitudes.)

3. Have your students locate the Tundra display, then use the snowshoe rabbit to open discussion on adaptations necessary for survival in this biome. Have students define adaptation, then work out at least three obvious adaptations for the rabbit. (Fur turning white in winter, large feet for walking over snow, and short, thick ears to help avoid frost bite.) Then move to other animals and ask for two or three other animal adaptations. Move on to plant adaptations and construct a food web. As you leave the biomes, ask for one state in this biome. (Alaska)

4. Move on around the displays discussing at least three plant and three animal adaptations--construct a food chain for each biome.

Total Time = 40 minutes.

Q 9. Tundra

Plant adaptations: Low, slow growth, rapid reproduction in the summer, thick skins, ability to hold water, shallow, branching root systems.

Animal adaptations: Wide feet, Caribou's snow scraping antlers, Snowshoe Rabbit's white color, Mountain Goat's hoofs, thick fur, short, thick ears, the Lemming's color.

Food chain: Moss → Snowshoe Rabbit → Wolverine → Fleas → Decomposer
Lichen → Lemming → Wolverine → Decomposer

Q 10. Northern Coniferous Forest

Plant adaptations: Evergreen trees able to make food continuously, cone shaped trees able to shed snow, taller trees are able to reach light, ferns able to exist in shady conditions, birch trees have winged seeds able to reach fire burned areas.

Animal adaptations: Porcupines with quill protection, beavers' behavior which builds their required habitat (ponds, lodges), fisher's behavior (he can kill a porcupine), Moose's nose enables underwater browsing, antlers for protection.

Food chain: Pine trees ⟶ Porcupines ⟶ Fishers ⟶ Tapeworm ⟶ Decomposers.
Birch trees ⟶ Beaver ⟶ Fox* ⟶ Lice ⟶ Decomposers.

*Could kill a young beaver.

Q 11. Middle Latitude Deciduous Forest

Plant adaptations: Trees able to produce leaves and grow quickly during warm weather, low growing plants able to grow in dim sunlight, vines able to reach light, tree shape broad to reach light but may be damaged by snow. Thick trunks to support the wide-spreading limbs.

Animal adaptations: Legs adapted for dodging, not speed, skunk scent, woodchuck's hibernate, turtles have protective shells, raccoons can climb to reach bird nests and protection.

Food chain: Seeds ⟶ Squirrels ⟶ Weasels ⟶ Bacterial Disease ⟶ Decomposers.
Leaves ⟶ Insects ⟶ Birds ⟶ Raccoons ⟶ Fleas ⟶ Decomposers.

Q 12. Desert

Plant adaptations: Thick, waxy stems able to make food. Needle leaves for protection. Quick reproduction following rains. Roots producing chemicals which retard growth of competing plants.

Animal adaptations: High ability to conserve water, behavior and cooling systems designed to withstand large temperature changes, many are able to climb on and eat cactus, poison in rattlesnakes. Peccary able to resist rattlesnake poison.

Food chain: Seeds ⟶ Kangaroo Mouse ⟶ Rattlesnake ⟶ Peccary ⟶ Ticks ⟶ Decomposer
Cactus ⟶ Peccary ⟶ Coyote* ⟶ Roundworms ⟶ Decomposer.

*Kill young peccary.

Q 13. Tropical Rain Forest

Plant adaptations: Small plants grow on large ones, collect water in bowls formed from leaves. Have wide, efficient leaves, have broad, shallow roots to trap surface minerals.

Animal adaptations: High ability to maneuver in trees, eyes focus ahead (binocular vision) as opposed to ordinary vision of the prairies, bright colored birds to enable mate attraction, thin fur coats.

Food chain: Seeds → Toucan → Monkeys* → Fleas → Decomposers.
Leaves → Insects → Monkeys → Snakes → Decomposers.

*Eat eggs and young.

Floor 3 (Optional)

The third floor displays material on the evolution of man, and early man's history in the United States. We have eliminated this floor from trips providing less than two and one-fourth hours in the museum. If time does allow, have students discuss the following questions.

Suggested presentation method for this floor:

1. Stop in front of the display on man's evolution, discuss question 14.

2. Point out the displays on Paleo and Archaic Indians, Woodland and Hopewellion Indians, Central Plains Farmers, and the displays on early man. Have students answer questions 15 through 19. Give them 10 minutes.

3. Review the questions, then move on to the next floor.

Total Time = 25 minutes.

Q 14. Would you expect the skulls in the display on the evolution of man to be real? Why?

A No. Skulls are rare, usually fragmented, and too valuable to put on public display. These are very carefully made replicas of the real skulls, which are housed in different museums throughout the world.

Q 15. When did early man first arrive in America?

A About 20,000 to 40,000 years ago. Ask your students if Indians were here before Christ was born. (Point out that they were here at least ten times longer than there were Christians on earth.)

What were Indians doing in Kansas when Columbus discovered America in 1492? (Farming)

Q 16. Compare the common foods and tools used by the following three groups of early men who lived in Kansas.

		Tools	Foods
A	Paleo and Archaic Indians ? - 0.B.C.	Arrows, Axes, Spears, Grinding Stones	Primarily animals and plants that were hunted and gathered, not cultivated.
	Woodland and Hopewellion Indians O.A.D. - 800 A.D.	Arrows, Spears, Axes, and Pottery	More plants in the diet, and some cultivated crops may have been added. Much hunting and gathering still used.
	Central Plains Farmers 800 A.D. - 1400 A.D.	Farming Tools, Pottery, Arrows, Spears, and so on.	Primitive corn and other cultivated crops are now added to meat that is hunted.

Point out to the students that the arrowheads were getting smaller as time progressed. Ask them to suggest reasons for this change. (Smaller game, more accurate arrows, better planned hunting trips, and difficulty of finding small arrowheads in older archeological sites, may all contribute to the trend toward smaller arrowheads.)

Q 17. Have men always caused other animals to become extinct, or is this a recent trait? What evidence can you find to support your theory?

A Since man has been on earth, he has played a part in causing other animals to become extinct. Fossil evidence indicates that each time primitive man invaded a new continent many of the large mammals soon died out. The best indication of this on this floor is that the Archaic and Paleo Indians hunted giant bison, elephants, horses, and camels in North America. All of these animals were extinct on this continent when white man arrived.

It should be made clear, however, that man is not solely responsible for extinction of other animals. Major die-offs occurred long before the earth even had large mammals. Man has added many, many animals to the list of extinct species, but he is not the only cause of extinction.

Ask the students why this trend of man's may be dangerous in the long run. Point out that a simplified food web can be destroyed much more easily than a complex web. Every new extinction simplifies our food web a little bit more.

Q 18. Were the societies whose artifacts are shown on this floor "worse" or lower than ours? Who should judge?

A Point out that societies can be judged on many facets. For instance, crime, health, economic growth, pollution, size, intelligence, and distribution of wealth are all things on which societies could be judged. No one society is the best in all areas.

Q 19) What fossil evidence would be needed in order to say that the center displays on ancient man were accurate, rather than merely possible?

A We have enough fossil evidence to be fairly sure of tools, animals eaten, posture, size, and musculature of the men and women. We would need more evidence of paintings or writings to determine color, hair covering, and social patterns as depicted in the paintings.

FLOOR 4

Throughout this floor, one concept in biology should be stressed. The concept is that most animals have a limited supply of energy available to them. This is energy they get as food, and the animal which is going to survive is the one which makes the best use of its energy. Energy is needed for reproduction, as well as just to keep the animal growing and alive. The animals best suited for their environment are those which can tap a large, steady supply of food and utilize it efficiently.

In reproduction, the best parents produce the greatest number of young which will survive to reproduce young of their own. Several strategies are used to reach this "maximun of successful young." For instance, the cowbird puts a lot of energy into the laying of eggs, but very little into supplying food and protection for its young. Other birds, like the Morning Dove, lay only two eggs at a time, but put a lot of energy into the care and feeding of their young. The goal is not to produce great numbers of young, but to produce enough young that one per parent reaches adulthood and reproduces. Oysters and tapeworms may lay millions of eggs to achieve this. Primitive man had several children. Modern man need average only slightly more than one birth per adult.

An immediate response to this concept is that humans, (and other animals) must strive to produce the maximum number of young to fit the "Survival of the Fittest Law." However, if too many young are produced, all may die through starvation, disease, or predation. Examples of these are viruses, which may overproduce and kill their host and lemmings which follow wildly swinging population cycles of overproduction, then starvation.

Suggested Presentation Methods for This Floor

1) If your students have adequate motivation and ability, show them the displays dealt with in the questions. Ask each student to answer at least six of the questions, and give the group 15 minutes to work independently. Review the questions as a group before leaving the floor.

2) If you have a low ability and/or poorly motivated group, give them five minutes to examine the floor's displays, then work with them on each display.

Total Time - 30 minutes.

Q 20) Why is the Cowbird called a parasite when it lives on seeds and insects?

A The Cowbird is a brood parasite. It acts as a parasite on other animals by laying eggs in their nests. The Cowbird lays about 15 to 25 eggs in its season, and can parasitize over 35 species of birds. These birds are generally about the same size as the Cowbird, so the eggs are roughly the

same size. Two things to emphasize here are that 1) any parasite must have many young in order to survive, since any host animal soon develops defenses against the parasite and 2) the Cowbird uses most of its available energy to lay eggs, rather than to rear its young.

The supplemental papers, "Why Do Robins Lay Blue Eggs?" and "Safety in Numbers" on pages 33-35 will provide some good background for discussion of questions 20 and 21.

Q 21) Suggest two adaptations which would help birds avoid parasitism by Cowbirds.

A See the papers suggested above for a more complete discussion. The two most probable adaptations are 1) egg color, shape, and/or size change to allow the birds to differentiate between their own eggs and the Cowbird's eggs and 2) Behavioral changes which enable the bird to toss an abnormal egg.

Q 22) Of what use are owl pellets to ecologists?

A These are pellets of the Long Eared Owl. The owl pellet is the regurgitated (spit up) fur, hair, and feathers of its prey. By collecting and analyzing the pellets, the ecologist can determine the diet for each owl. The pellets show what animals and how many of each kind of species were eaten. This data not only helps determine what the owl eats at night, but can also provide information on changes in rodent population. Point out that 99% of the owl's diet is rodents.

Q 23) Give two advantages that dark pigment gives to bird feathers and the bird.

A This is from a display on albino birds. It explains why albinoism is a bad trait. 1) Albino birds are more easily spotted by predators, 2) The melanin (dark pigment) gives the feathers much greater endurance, and 3) The albino will have more trouble attracting a mate. Thus, albino birds are more quickly killed and less likely to produce young.

In discussing this question, ask whether a mutation for albinoism would lead to an adaptation in most birds. (It would <u>not</u>, because it does not encourage more successful reproduction.)

Q 24) How could insecticides destroy the yucca plant?

A The relationship between the <u>Yucca Plant</u> and the <u>Pronuba Moth</u> is an example of inter-dependence of plant and insect. Neither one could survive without the other. The Pronuba Moth <u>pollinates</u> the yucca plant, and the yucca plant <u>provides food for the moth</u>. If you killed the moth, you would also kill the yucca plant, since it could no longer reproduce. (Many high school students do not know that pollination leads to reproduction and seed production.)

Q 25) What advantage would birds gain by adapting to eating plants, not insects and animals?

A Along the west wall of the K. U. Museum, there is a display of Kansas birds. It points out that there are over 400 different species, and sub-species, of birds in Kansas. The display is set up from primitive to advanced birds.

The primitive birds (such as the Brown Pelicans, Swans, Vultures, Loons, Geese, and Bald Eagles) are more closely related to the reptiles, from which birds came, than the more modern birds, such as Sparrows. All birds, of course, have changed drastically from the early birds of several million years ago.

Have the students compare the bird's bills going from primitive to advanced birds. This is one of the best indications of bird changes. You gradually go from hooked bills and predatory birds to smaller bills such as those used for catching insects in flight. You then move into the Bobolinks and Meadowlarks, where the first bills adapted for seed eating appear. Finally, the Sparrows, Juncos, Buntings, and Goldfinches have short, stout bills used for cracking seeds. Thus, the more modern birds depend upon seeds and smaller insects.

The easy answer to this question is that plants provide a more bountiful and dependable source of food than do animals. The question can be pursued much deeper if your students are up to it. (As man's population increases, we will need to eat more and more plant food because of its prevalence, i.e. increasing difficulty in obtaining meat.)

The more advanced birds are adapted to eating seed plants because flowering plants evolved after seeds were available. These foods can now supply a steady and reliable diet for many birds, and the modern birds have adapted accordingly. One interesting note - the birds most endangered by pesticides are the predatory and more primitive birds.

Q 26) What are three things which influence the number of eggs laid by one species of birds?

A Adults' health, weather, competition from other birds, length of day (to gather food), availability of food, and chance all play a part in determining the clutch size of most birds.

Q 27) A medium-sized bird lays its eggs in holes in trees and has young which quickly leave the nest. Predict the color, size, and shape of its eggs.

A

Prediction		Reason for Prediction
Color	White	The basic egg is white. It takes energy to supply the cells to produce colored eggs. If colored eggs do not help the birds reproduce mutations to make colored eggs will not become an adaptation. Eggs laid in holes in trees may as well be white, because they don't need camouflage. Therefore, the eggs will be white, since energy to color them would be wasted.
Size	Large	If chicks are able to leave the nest quickly, they must have a larger egg to supply enough food and growing room.
Shape	Oval not	Oval eggs contain the maximum amount of food for a set diameter. Therefore, the egg will be oval unless the bird uses a flat surface such as rock ledges and open fields for its nests. In this case, a pear shaped egg will have an adaptive advantage, since it will roll in circles.

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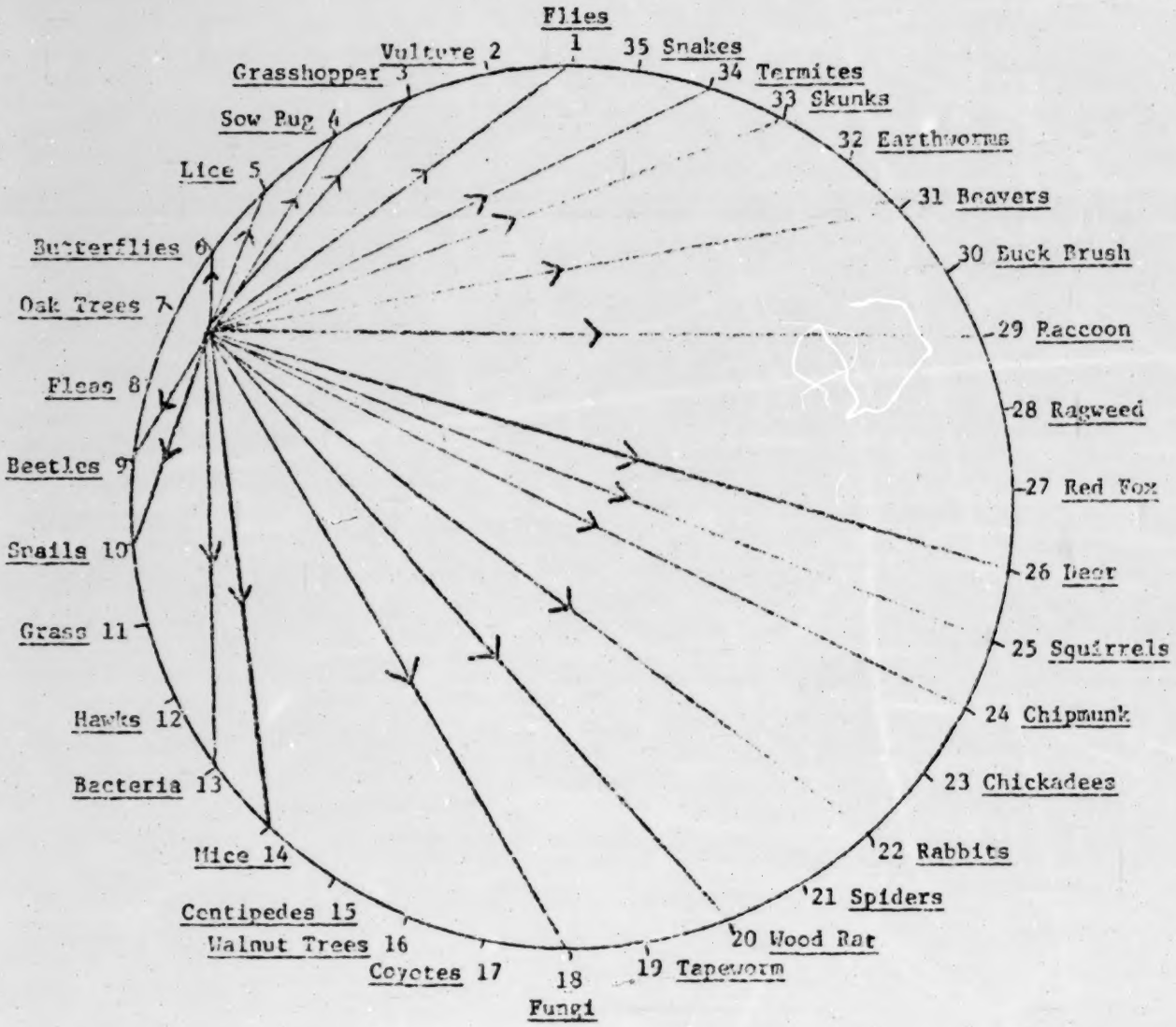
Module: 5

Transparency 1
Paper G

Food Web Exercise

1. Draw a line between the organism assigned to you and all organisms eating and/or being eaten by it.

2. In the middle of each line, place an arrow pointing toward the higher order consumer. (sparrow ←— seed) If the populations may use each other, indicate with two arrows. (deer ←→ fungi)



Oak Trees

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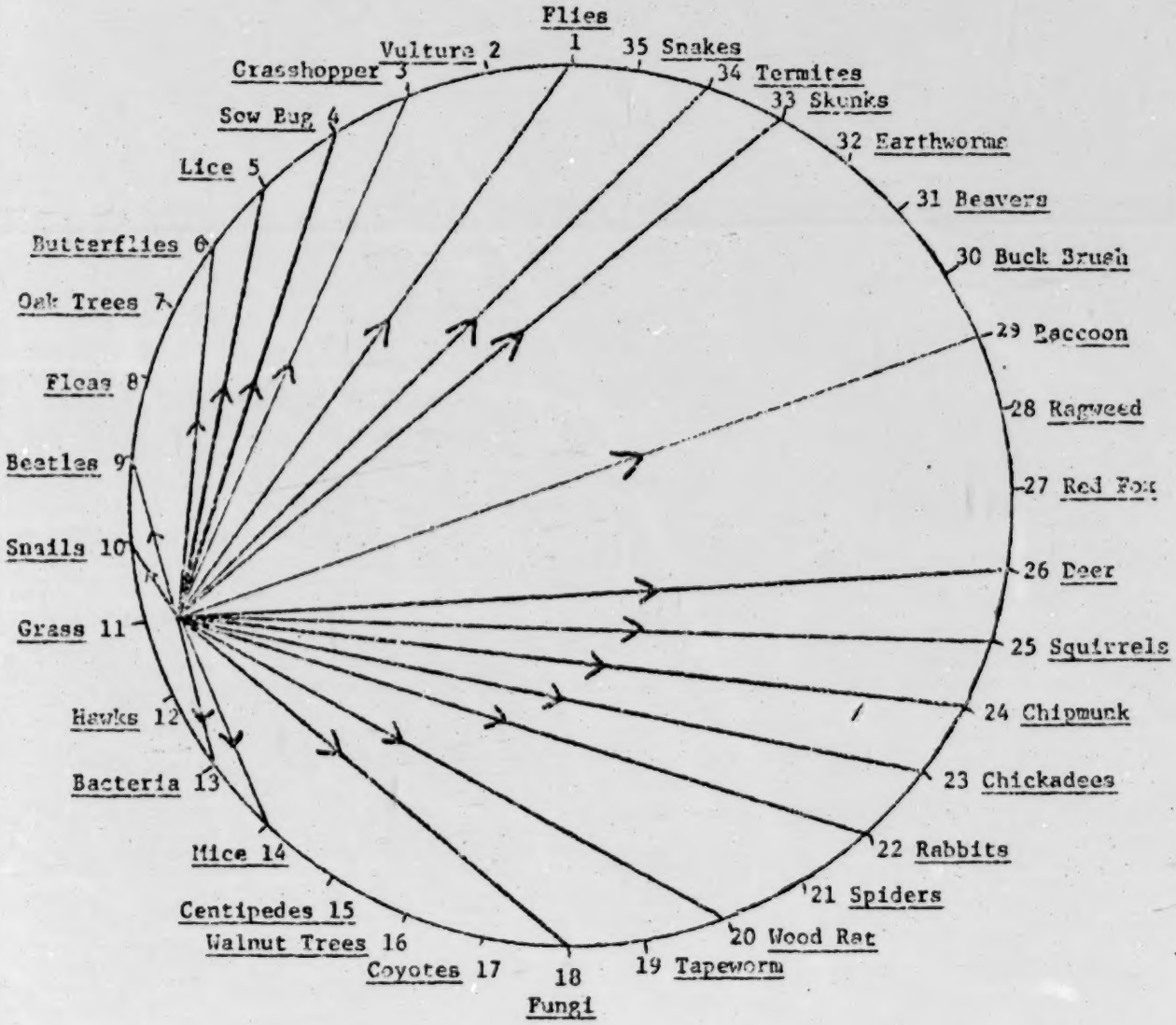
Module: 5

Transparency 2
Paper G

Food Web Exercise

1. Draw a line between the organism assigned to you and all organisms eating and/or being eaten by it.

2. In the middle of each line, place an arrow pointing toward the higher order consumer. (sparrow ←— seed) If the populations may use each other, indicate with two arrows. (deer ←→ fungi)



Grass

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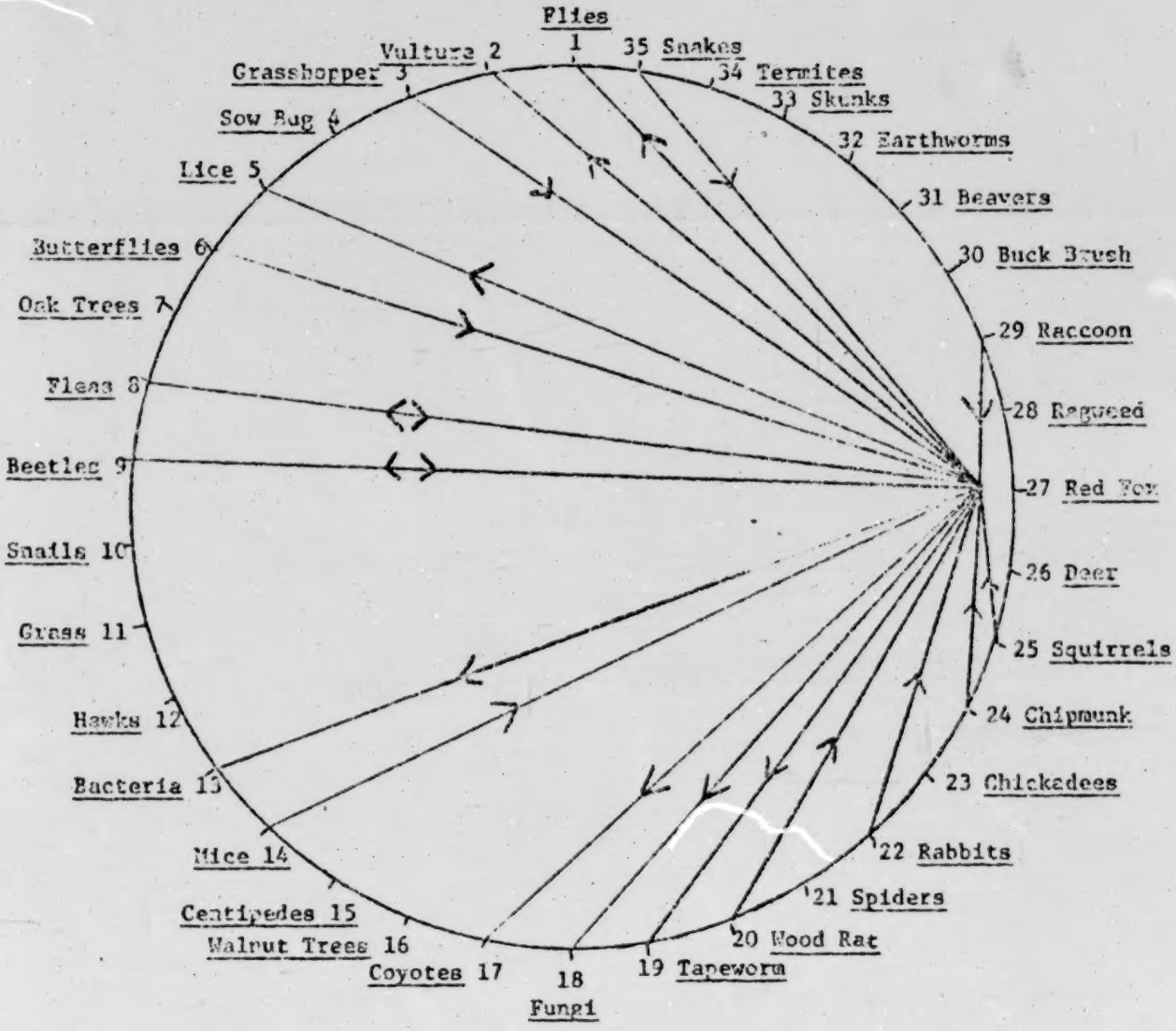
Module: 5

Transparency 3
Paper G

Food Web Exercise

1. Draw a line between the organism assigned to you and all organisms eating and/or being eaten by it.

2. In the middle of each line, place an arrow pointing toward the higher order consumer. (sparrow ⟵ seed) If the populations may use each other, indicate with two arrows. (deer ⟷ fungi)



Red Fox

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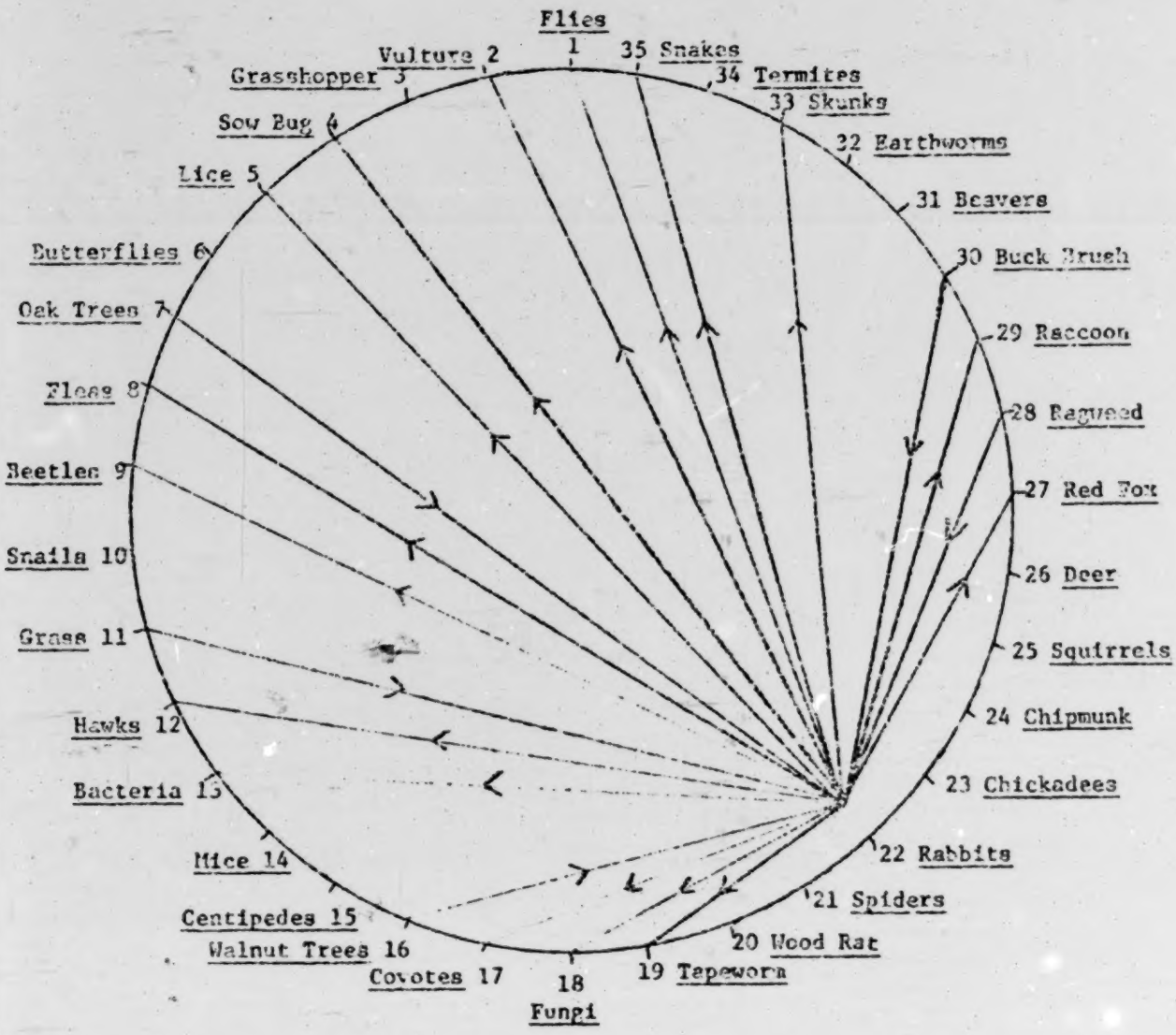
Food Web Exercise

1. Draw a line between the organism assigned to you and all organisms eating and/or being eaten by it.

2. In the middle of each line, place an arrow pointing toward the higher order consumer. (sparrow ——<—— seed) If the populations may use each other, indicate with two arrows. (deer ——<——>—— fungi)



Rabbits

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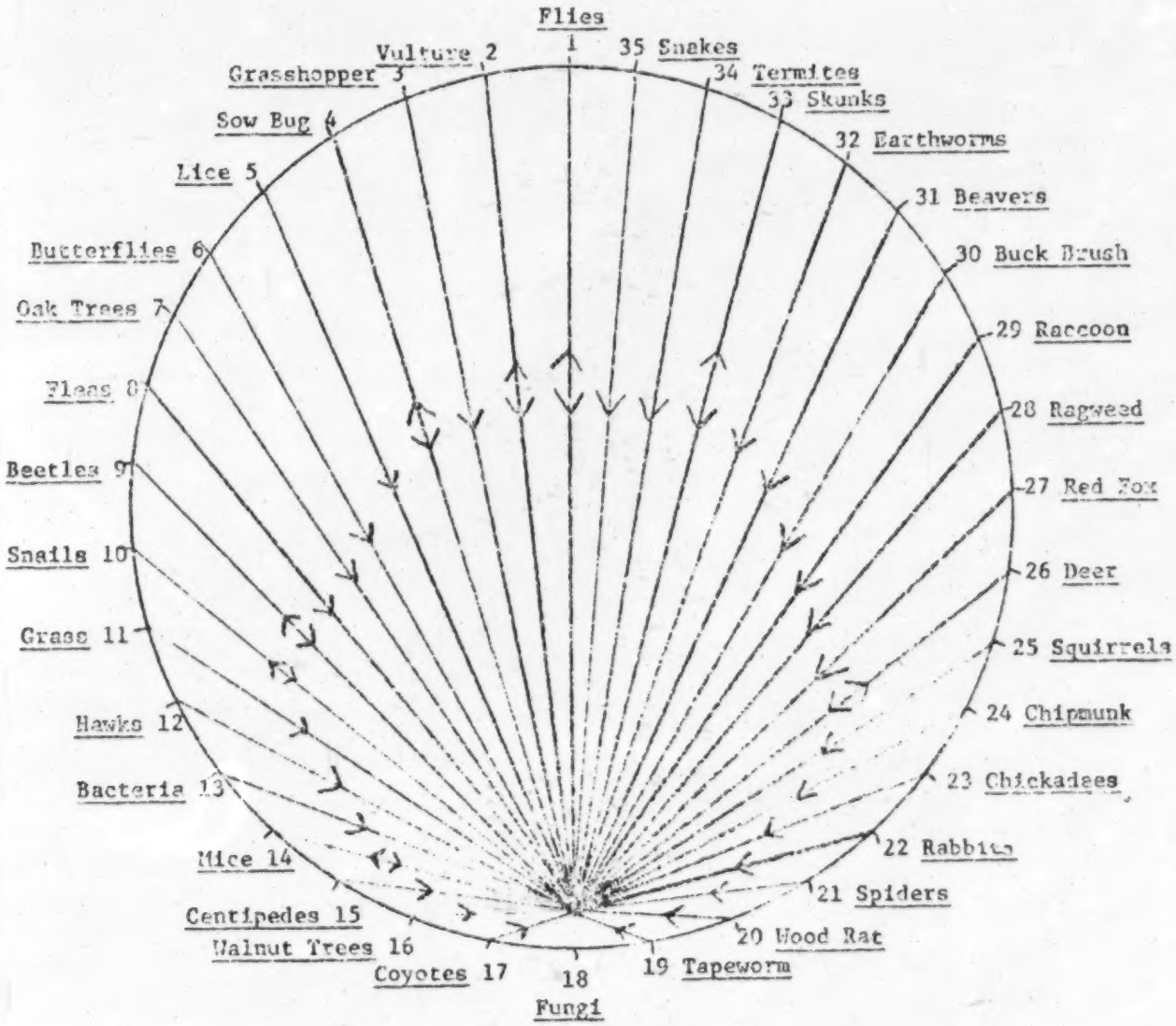
Food Web Exercise

1. Draw a line between the organism assigned to you and all organisms eating and/or being eaten by it.

2. In the middle of each line, place an arrow pointing toward the higher order consumer. (sparrow ——<—— seed) If the populations may use each other, indicate with two arrows. (deer ——<——>—— fungi)



Fungi

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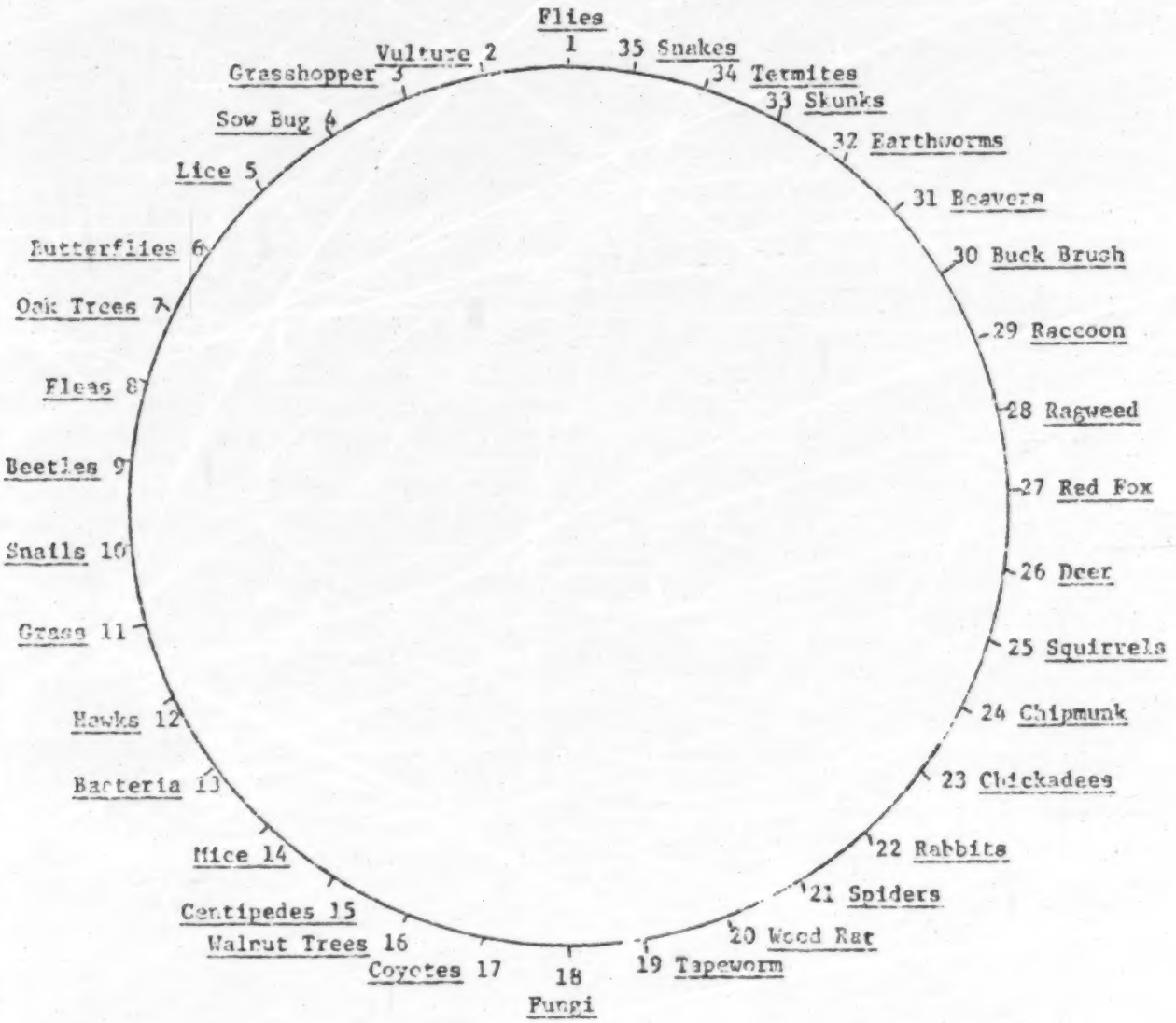
Module: 5

Transparency 6
Paper G

Food Web Exercise

1. Draw a line between the organism assigned to you and all organisms eating and/or being eaten by it.

2. In the middle of each line, place an arrow pointing toward the higher order consumer. (sparrow ——←—— seed) If the populations may use each other, indicate with two arrows. (deer ——←→—— fungi)